

QL
461
U58
ENT

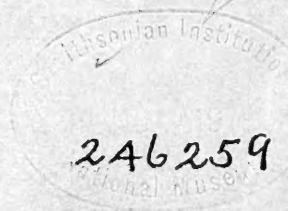
Minnesota. State Entomologist
...

Seventeenth Report

State Entomologist of Minnesota

To the GOVERNOR

By A. G. RUGGLES



Agricultural Experiment Station
University Farm, St. Paul, Minnesota
December 1, 1918



QL
461
758
ENT

Minnesota. State Entomologist.

Seventeenth Report State Entomologist of Minnesota

To the GOVERNOR

By A. G. RUGGLES



SUBJECT INDEX

	Page
General report on insect conditions in 1918, Publications, Financial Statement and List of Nurserymen. By A. G. Ruggles.....	3
Life History of an Oak Twig Girdler, (<i>Agrilus arcuatus</i> Say and var. <i>torquatus</i> Lec.) By A. G. Ruggles.....	15
Potato Spraying in Minnesota. By S. A. Graham.....	21
The Carpenter Ant as a Destroyer of Sound Wood. By S. A. Graham....	32
Drosophila in Bottled Certified Milk. By Wm. A. Riley.....	41
Contribution to Knowledge of the Tribes and Higher Groups of the Family Aphididae (Homoptera). By O. W. Oestlund.....	46
The Confused Flour Beetle (<i>Tribolium confusum</i> Duval). By R. N. Chapman	73
The Clover Seed Chalcid (<i>Bruchophagus funebris</i> Howard). By Warren Williamson	95
A Preliminary Report on the Trombidiidae of Minnesota. By C. W. Howard	111
The Hymenoptera of Minnesota. By F. L. Washburn.....	145
Minnesota Barberry Eradication Law.....	239

Agricultural Experiment Station
University Farm, St. Paul, Minn.
December 1, 1918

Published April 10, 1919

December 1, 1918.

To His Excellency J. A. A. Burnquist,
Governor of the State of Minnesota.

Dear Sir:

In compliance with the Revised Laws of Minnesota 1905, Chapter 38, Section 2382, I have the honor to present herewith a report of the State Entomologist for the year ending December 1, 1918.

A typewritten report for the year ending December 1, 1917, covering the year's work in nursery inspection and other duties of the State Entomologist was sent you in December, 1917, by Professor Washburn and a published report of the work on the White Pine Blister Rust by Mr. Washburn took the activities of the State Entomologist practically up to February, 1918. At that time the writer assumed the duties of this office, Professor Washburn having resigned the office of State Entomologist to continue his work in the university as zoologist of the Experiment Station.

As the insect work of the year 1918 had not begun, plans for the growing season were developed immediately. There were two main phases of the work to be kept in mind; one the purely mechanical work of inspection, and the other the carrying on of plant pest campaigns. Besides these two main functions, experimental insect control problems had to be conducted in connection with the Experiment Station work. The policy adopted was that the two main functions mentioned should be carried on at the same time; that the nursery inspection work should be closely merged with the educational or extension work and that the inspectors would then be looked upon not as policemen but as associates and helpers. The policy was to work in every possible way to keep plant pests out of the state, but if any should become established, to find the best method of controlling them and assist the nurseryman, orchardist, gardener and others in their control.

This policy was followed very closely during the last season and has produced excellent results.

As the chapter of the Minnesota law previously quoted makes the State Entomologist responsible for combating insect pests and plant diseases, the work this year naturally divided into four groups:

1. The inspection of nurseries;
2. The control of white pine blister rust;
3. The eradication of the common barberry;
4. The study of life histories and control measures for insect pests.

FIELD CROP INSECTS

Two or three regions in the state were threatened this year with a grasshopper outbreak. In two instances considerable damage was done. From May to July we were very fortunate in procuring through the United States Department of Agriculture an extension man for field crop insects. Mr. Marshall Hertig, a graduate of Minnesota, was sent here at our request and we were well satisfied with his work. When the work was at its height he was called in the draft and is now serving the country in France. Mr. Hertig devoted his time principally to the grasshopper situation. He had it well in hand and was planning a vigorous campaign for the fall and winter among the farmers.

White grubs did considerable damage, but as this was not the year for their worst attack, we are planning a campaign for 1919 and 1920.

The sugar beet web worm made its appearance and did considerable damage to sugar beets, flax and clover in Chippewa, Kandiyohi, Grant and Polk counties. At Clara City, we tried arsenate of lead powder in a power dusting machine. The insects were controlled, but whether the cost of spraying warrants such a control method is yet to be determined.

Wireworms did considerable damage in small areas of the state and continue to offer interesting problems. To date, no solution of the difficulty has been found.

Probably by far the most important insect of the garden was the cutworm. During the cutworm season from twenty to thirty telephone calls a day and innumerable letters pertaining to this insect were received. In almost every case where poisoned bran mash was used as directed, the cutworms were easily kept in check.

TREE INSECTS

Among the numerous orchard insects which have made their appearance in the state is the leaf crumpler of the apple. The increasing abundance of this pest offers further problems for investigation.

Tussock moths and canker worms are still on the increase. It is only where communities decide upon vigorous co-operative measures that these pests will be kept in control.

The oak twig girdler was in evidence this year, doing a great amount of damage to the oaks of the lawns and boulevards. Unfortunately the only control measure is the very expensive one of cutting out all diseased branches of the affected trees and burning them with their insect contents.

Carpenter ants are responsible for an immense amount of damage to standing white cedar in the northern part of the state. The infestation varies from 15 to 20 per cent of all swamp trees of pole size and from 40 to 75 per cent of the trees on higher ground. S. A. Graham, of this department, has investigated the injury. He believes that altho it is impractical to suggest methods of protecting the standing trees from injury by ants, the loss occasioned by them may be reduced to comparatively small proportions if we *discourage wasteful practices in the woods.*

POTATO SPRAYING

In an experiment to determine the comparative value of lead arsenate, calcium arsenate, zinc arsenite and paris green, it was found that when applied under favorable conditions, the poisons were equally effective in poisoning the colorado potato beetles. The favorable condition necessary is dry weather such as we had in 1918 which makes it possible for the poison to remain on the plants for a long time. Under less favorable conditions, those materials which are easily washed from the leaves would have been the less effective.

These results show that two factors determine the comparative value of the stomach poisons: (1) Ability to stick in spite of rains and (2) the cost.

Preliminary work in testing the power of adherence of these compounds indicates that both lead arsenate and calcium (lime) arsenate are resistant to washing, while paris green washes off very readily. Calcium arsenate (arsenate of lime) is the cheapest of these poisons and therefore is the most desirable for potato spraying.

Experiments for the control of leaf hoppers on potatoes showed that the commercial tobacco extracts with soap were effective as contact sprays, provided the insects were hit with the material. The problem of leaf hopper control, therefore, is a problem of perfecting the mechanics of application.

ORCHARD AND NURSERY INSPECTION

During the entire growing season 146 nurseries have been inspected and 100 certificates issued. We have also given 11 certificates to dealers in nursery stock. For the most part the nurseries of the state were found to be in excellent condition. No dangerously injurious insect or disease was found, necessitating quarantining any nursery or refusing a certificate. In a few instances barberry eradication and white pine blister rust called for extra precautionary measures,

but our inspectors proved efficient and the condemned plants were destroyed. With the added work of barberry eradication and the extra vigilance necessary to keep injurious insects and diseases out of the state, an increase in the funds for nursery inspection must be made.

WHITE PINE BLISTER RUST

During the season just past, we have co-operated very closely with the United States Department of Agriculture on the control of white pine blister rust. The federal authorities spent practically \$20,000 in the state this last year, while the state spent \$7,500.

Three phases of the work were emphasized in Minnesota (1) scouting, (2) eradication, (3) nurseries and leads. To better the work in Minnesota, Dr. E. M. Freeman, chief of the division of plant pathology and botany of the Experiment Station, personally guided the work of scouting. Professor Cheyney, the forester of the Experiment Station, took personal charge of eradication and the writer the leads and nurseries. This arrangement, altho somewhat cumbersome in details of office work, worked out very nicely under the co-operative plan. The work is now so well in hand that next year, if the work continues, the State Entomologist will take immediate charge of the three phases of the project.

Like the black stem rust of wheat, the white pine blister rust has two hosts, each necessary before the disease can complete its life cycle—the common gooseberries and currants and white pines. If there were no currants and gooseberries, there would be no fear of the white pine being infested with blister rust. In the scouting work, therefore, the disease is looked for both on pine trees and currant and gooseberry bushes. The thirty places, for the most part in the Saint Croix Valley, reported last year as being infected, were scouted thoroly again this year as well as the entire country surrounding this area. In six of these places the disease was again found, but on only two areas had the disease spread beyond the area of infection of last year. The entire area around the infections for the width of two counties was scouted, and no disease was found. In the badly infested areas, the infested pines and gooseberries within a radius of one third of a mile were destroyed.

A total of 994 white pine plantings were inspected this year. In addition to this 353 leads were followed where no white pines were found. Approximately 110,000 white pines were inspected during the season, and 1,617 were destroyed to prevent possible infection. Five

new infections were found by means of the leads, but these were soon eradicated.

The small number of new infections found and the fact that the old infections are confined within rather narrow limits, seems very encouraging. In spite of the fact that it takes several years for the disease to show itself, we believe that there is a chance of entirely eradicating it within the state. If given an appropriation to continue the work for two years more, we shall be able either to eradicate the disease or to recommend means for keeping it under control. The white pine lumber of the state is so valuable that with such a possibility before us, it would seem folly not to spend the small appropriation needed for the trial.

BARBERRY ERADICATION

On March 19, 1918, the Minnesota Commission of Public Safety passed an order making the State Entomologist responsible for the eradication of the common barberry (*B. vulgaris*) and all its varieties. This order, No. 28, declared these bushes to be a public nuisance and a menace to the public welfare, and their maintenance, propagation, sale or introduction into the state was forbidden. Whenever these bushes were located, the owner was to be notified that these dangerous bushes were growing on his premises and that he must forthwith destroy them.

The United States Department of Agriculture had at this time already started a campaign of education regarding the dangerous character of these plants, and as federal scouts were at work in the state, a hearty co-operation was effected. Much publicity had been given to the movement and probably four or five times as many bushes as we have actual record of, were destroyed before active scouting occurred. To date, all the counties of the state have been scouted except three, and in two others no barberries have been found. We have records of more than 50,000 plants dug up and destroyed from the ordinary plantings of city, town and summer residence lots. In the nurseries of the state, where we can get more absolutely accurate counts, 607,434 bushes have been destroyed.

The rust investigators from the different states have observed many interesting facts in the relationship of the barberry to the black stem rust of grains this year. In some states every single infection of rust investigated was directly traceable to barberry. As many instances have been found where the barberries have begun to grow wild in this state, we believe the campaign for their eradication was started

just in time. The good effect on the grain growing industry can already be noticed and it is hoped that adequate legislation will put the barberry in its proper place with all the other huns.

A list of publications issued by this department, together with the financial statement and the list of Minnesota nurserymen are appended.

Respectfully submitted,

A. G. Ruggles,

State Entomologist.

PUBLICATIONS

CIRCULARS

No. 46.	Jan. 15, 1918, The Hydrocyanic Acid Gas Treatment for the Flour Moth - - - - -	<i>Washburn</i>
No. 47.	Mar. 25, 1918, Some Insects Injurious to the Potato -	<i>Graham</i>
No. 48.	Apr. 1, 1918, Spraying - - - - -	<i>Ruggles</i>
No. 49.	Apr. 15, 1918, Insects of the Home Vegetable Garden -	<i>Graham</i>
No. 50.	Apr. 20, 1918, Insects Injurious to Small Fruits -	<i>Graham</i>
No. 51.	May 1, 1918, Fruit Tree Cankers and Their Control -	<i>Stakman & Newhall</i>

QUARANTINE

No. 3.	April 1, 1918, All Barberry (<i>Berberis</i> sp.) bushes except the species and variety known as Japanese barberry (<i>Berberis thunbergii</i>). - - - - -	<i>Ruggles</i>
--------	---	----------------

FINANCIAL STATEMENT

STATE ENTOMOLOGIST

Appropriation		\$6,300.00
Expenditures		
Salaries	\$3,741.30	
Expense and travel	324.17	
Printing and publishing	909.71	
Office supplies	59.06	
Freight and express	12.52	
Postage	141.00	
Telephone and telegrams	87.78	
Photos, cuts, engravings, etc.	306.99	
Furniture and equipment	342.34	
Miscellaneous	373.22	\$6,298.09
Balance		\$1.91

NURSERY INSPECTION

December 1, 1916 to August 1, 1918

Balance, Dec. 1, 1916	\$1,229.54	
Appropriation, 1917-18	3,000.00	
Cr. from nursery inspection fees 5/9/18	20.00	\$4,249.54
Expenditures		
Salaries	\$3,191.50	
Travel and expense	883.51	
Office supplies	28.60	
Postage	50.00	
Printing	89.00	
Unused balance 1916-1701	\$4,242.62
Balance Aug. 1, 1918		\$6.92

Collections—Nursery Fees

Cash on hand, December, 1916	15.00	
98 certificates issued to nurserymen (1917)....	490.00	
8 certificates issued to dealers (1917).....	40.00	
19 certificates issued to nurserymen (8/1/18)..	95.00	
3 certificates issued to dealers (8/1/18).....	15.00	\$655.00

Deposited with the State Treasurer:

1917	
May 1	\$30.00
June 7	10.00
August 3	25.00
August 13	30.00
September 17	70.10
October 14	65.00
October 29	100.00
November 17	110.00
November 28	65.15
December 19	35.00

1918		
January 16	5.00	
March 30	40.00	
April 22	15.00	
*May 9	20.00	
		\$655.25†

WHITE PINE BLISTER RUST

August 1, 1917 to August 1, 1918

August 1, 1917, balance forwarded	\$5.53	
August 1, 1917, balance of appropriation	2,500.00	
March 14, 1918, credit from 1919 appropriation	4,500.00	\$7,005.53

Expenditures

Salaries	\$3,069.01	
Expense and travel	1,868.34	
Printing and publishing	104.50	
Office supplies	85.29	
Freight and express	25.57	
Groceries and camp equipment	304.67	
Photos, cuts, etc.	26.41	
Furniture and equipment	679.48	
Labor	554.80	
Miscellaneous	81.98	\$6,800.15

Balance		\$205.48
---------------	--	----------

Expended on

Nurseries and leads	\$2,147.39
Scouting	2,414.02
Eradication	2,238.64
Total	\$6,800.15

*Credited to inspection fees under 206 G. L. 1913.
 †25c for collection charges on country checks.

NURSERIES INSPECTED

SEASON 1918

Town	Nursery	Proprietor
Albert Lea	*The Albert Lea Nursery	O. M. Peterson
Albert Lea	†Minnesota State Nursery	E. C. Eaker
Albert Lea	*The South Side Nursery	Martin Fridholm
Albert Lea	*Wedge Nursery	Clarence Wedge
Alexandria	*Alexandria Fruit Farm	W. H. Horton
Arago	*College of Forestry	State of Minnesota (Also Cloquet)
Askov	*The Askov Nursery	A. Bobjerg
Atwater	Atwater Fruit Farm	Peter Peterson
Austin	The Austin Nursery	C. F. Woodle
Austin	†A. N. Kinsman, Inc.	Austin Greenhouses
Austin	*The Turtle Creek Nursery	J. M. Lindsay
Bagley	The Herschberger Nursery Farm	
Battle Lake	*The Swedberg Nursery	J. E. Swedberg
Beltrami	*Johannessohn & Co. Nursery	Johannessohn & Co.
Bemidji	*Beltrami Nursery & Greenhouses	Otto Brose
Bemidji	George C. Berglund	
Buffalo	Wah-wah-taysee Lodge	T. W. Ingersoll
Brainerd	Peter A. Erickson	
Byron	*The Byron Nursery	F. E. Cutting
Cambridge	Oslund's Nursery	N. N. Oslund
Canby	*Sivert's Nursery	Peter Sivert
Canton	*Fillmore County Nursery	George F. Snyder
Cloquet & Arago	*College of Forestry	State of Minnesota
Cokato	†J. W. Beckman	
Cokato	*John Eklof	John Eklof
Cokato	Cokato Berry Farm	Fayette Lee
Crookston	Crookston Substation	University of Minnesota
Crookston	*Schuster Nursery	E. W. Schuster
Delano	*The Delano Nursery	Charles Sell
Dassel	W. C. Ferguson	
Delano	C. A. Brunkow	
Eagle Bend	*Taylor's Eagle Bend Nursery	T. W. Taylor
East Grand Forks	East Grand Forks Nursery	Oscar Wick
East Grand Forks	*The Loudenback Nursery	F. M. Loudenback
Excelsior	*Brackett Nursery	A. Brackett
Excelsior	*The Deephaven Nursery	Alfred O. Hawkins
Excelsior	*The Highlands Fruit Farm	C. P. Jackson Land Co.
Excelsior	The Hawkinson Nursery	Charles Hawkinson
Excelsior	*Minnetonka Old Fashioned Flower Garden	Mrs. N. S. Sawyer
Excelsior	Mirror Lake Farm	J. K. McBroom
Excelsior	*O. H. Seaman's Nursery	O. H. Seaman

Town	Nursery	Proprietor
Excelsior	Thurman's Nursery	W. J. C. Thurman
Zumbra Heights (P.O. Excelsior)	*University Fruit-Breeding Farm Nursery	University of Minnesota
Excelsior	*Zumbra Heights Fruit and Poultry Farm	August Sauter
Fairmont	†The Commercial Nurseries of Fairmont (Dealers)	O. B. Dokken
Fairmont	*Amber Lake Nursery	P. C. Christensen
Fairmont	*Fairmont Nurseries	G. D. McKisson
Faribault	*The Andrews Nursery	C. H. Andrews et al.
Faribault	*Brand Nursery Co.	A. M. Brand
Faribault	*Farmer Seed and Nursery Co.	Wm. Kueker
Faribault	†The Northern Nurseries Co. (Dealers)	F. L. Gorman & C. J. Claybaugh
Faribault	Wood Crest Farm	C. H. Smith
Farwell R. F. D. 1	*Claus Osterberg	
Freeport	*The Wilwerding Nursery and Apiary	A. J. Wilwerding
Garden City	*Mills Lake Nursery	L. D. Mills
Glenville	*Floral Mound Nursery	J. J. Peterson
Grayling	*The Lake View Nursery	Victor Carlson
Halstad	*Evergreen Nursery	Rev. O. A. Th. Solem
Hamel	*Hugharts' Sons Nursery	Hugharts' Sons
Hasty	*Wright County Nursery	J. S. Elofson
Houston	*Vinegar Hill Nursery	Wm. Sandrock
Howard Lake	*Howard Lake and Victor Nurseries	W. H. Eddy
International Falls	*International Falls Nursery	School District No. 4
Kelliher	I. W. Gehron	
Kenyon	Kenyon Nursery	J. A. Mogren & Son
Kenyon	*The Oak Grove Nursery	P. H. Volstad
Kenyon	*The South Kenyon Nursery	E. J. Hershaug
Kimberly	*Ayres' Jack Pine Nursery	H. B. Ayres
La Crescent	Sunnyside Fruit Farm	F. J. Harris
La Crescent	H. Vollenweider	
Lake City	*N. E. Anderson Nursery	N. E. Anderson
Lake City	*The Jewell Nursery Co.	J. M. Underwood
Lake City	†The Johnson Nursery	P. G. Johnson, 3300 Elliott Av. So., Minneapolis
Lake City	*National Nursery Co.	J. L. Anderson
Lake City	*Tolleson Nursery Co.	G. A. Anderson
Lakeland	*Mayfield Nursery	L. L. May & Co., St. Paul
Lamberton	The Motter Nursery	Julian P. Motter
Lindstrom	*The Chisago Lake Nursery	Ludwig Carlson
Litchfield	*The Ferguson Nursery	W. C. Ferguson
Long Lake	*The Daniels Nursery	Franc P. Daniels
Long Lake & Minneapolis	John H. Hirt Nursery	John H. Hirt
Lonsdale	*Lonsdale Nursery	John P. Vikla
Luverne	*Luverne Nursery	C. E. Older

Town	Nursery	Proprietor
Mabel	R. Spande	
Mabel	O. L. Christopherson	
Madison	*The Madison Nursery	M. Soholt
Mankato	*Mankato Nursery	L. Z. Smith
Mankato	†M. M. Sinotte (Dealer)	
Mantorville	*Dodge County Nursery	W. E. Fryer
Marshall	*Minnesota State Nursery	E. C. Eaker
Marietta	*Orton Park Nursery	C. J. Orton
Medford	*The Medford Nursery	Grace Patten Eaton
Medford	*The Deerfield Nursery	L. A. Schoen
Mildred	C. B. Finsaas	
Minneapolis	*Harry Franklin Baker	4629 Lake Harriet Blvd.
Minneapolis	*Board of Park Commissioners	Court House
Minneapolis	†W. H. Bofferding Co. (Dealers)	7th St. at 2d Av. N.
Minneapolis	*Cedar Hill, C. N. Reudlinger, St. Louis P'k, Bx. 114	
Minneapolis	*The Farmer Nursery	E. A. Farmer, Linden Hills Sta.
Minneapolis	*C. C. Hunter	5700 Nicollet Ave.
Minneapolis	†Northrup King & Co. (Dealers)	1st St. and Hennepin Ave.
Minneapolis	*Rose Hill Nursery, John Hawkins, Como and Eustis	
Minneota	*Teigland's Nursery	J. L. Teigland
Montevideo	*The Variety Fruit Farm	M. Oleson
Monticello	Monticello Nursery	— Bateman
Nemadji	*Combercroft Farm and Nurseries, G. E. MacComber	
Nevis	Nevis Fruit Breeding Station	Jas. Arrowood
New Brighton	*Lakeside Poultry Farm	F. J. Hipp
Newport	*The Bailey Nursery	J. V. Bailey
New Ulm	*Pioneer Nursery Co.	Wm. Pfaender, Jr.
Nisswa	*Lundborg Bros. Nursery	
Northfield	The Northfield Seed and Nursery Co.	P. M. Punderson
No. St. Paul	No. St. Paul Horticultural Farm	J. K. Dixon
Olivia	Dunsmore Nursery	Henry Dunsmore
Onamia	*The Wyse Nursery	Oliver Wyse
Owatonna	*The Clinton Falls Nursery Co.	Thos. E. Cashman
Owatonna	*The Mitchell Nursery	D. M. Mitchell
Owatonna	*Owatonna Nursery Co.	L. J. Wesely
Paynesville	*The Elmwood Select Nursery	Frank Brown & Son
Perham	J. H. Bauer	
Pine City	Minnesota Northern Nurseries	O. J. Graham
Preston	*The Preston Nursery	C. E. Snyder
Princeton	H. J. Lowell	
Princeton	J. O. Runsten	
Rochester	Evergreen Lawn Fruit Farm	H. W. Harrison
Rockford	The Lake Sarah Specialty Farm	F. C. Erckel
Rush City	*The R. E. Killmer Nursery Co.	R. E. Killmer
St. Cloud	†The St. Cloud Nursery Co. (Dealers)	
St. Hilaire	*Park Ridge Nursery	S. J. Amble & Son

Town	Nursery	Proprietor
St. James	*St. James Nursery	J. J. Hill
St. Joseph	Matthew Reinsinger	
St. Paul	C. E. Ammundson Nursery	
	C. E. Ammundson, 1960 E. Minnehaha	
St. Paul	*J. C. B. Andersson Nursery	
	J. C. B. Andersson, 1285 Portland Ave.	
St. Paul	†Emporium Mercantile Co. (Dealers)	7th and Robert
St. Paul	*Hoyt Landscape Nurseries	
	W. T. March, Hoyt and Hamline Aves.	
St. Paul	Killmer's Northern Nurseries	
	E. C. Killmer, 1511 Raymond Ave.	
St. Paul	*The Park Nurseries	
	Holm & Olson, Inc., 20 W. 5th St.	
St. Paul	Rainbow Gardens	
	John S. and Grace Crooks, 1980 Montreal Ave.	
St. Paul	*Riverview Gardens	A. J. Wilkus, 909 Winslow Ave.
St. Peter	*Nicollet County Nursery	C. Edwin Swenson
Sacred Heart	*Sacred Heart Nursery	J. Flagstad & Sons
Starbuck	*Minnewaska Nursery	Paul J. Klevann
Spring Valley	Spring Valley Nursery	Frank Waskosky
Taylor's Falls	*Strand's Nursery	G. W. Strand
Tyler	*The Tyler Nursery	J. P. Eriksen
Vergas	*E. L. Thomas & Son	
Waltham	*Maplehurst Nursery	Grace E. Kimball
Wayzata	*The Cabinwood Nursery	S. J. Wetherald
Wayzata	*Ferodowill Nurseries	F. X. Ferodowill
Wayzata	*The Minnetonka Nursery	Douglas Winter
White Bear	A. E. Hooker	
Winnebago	*The S. D. Richardson Nursery	S. D. Richardson
Winnebago	The Winnebago Nursery	— Peck
West Concord	*West Concord Nursery	Fred J. Cowles
Winona	*The Pfeiffer Nursery	C. A. Pfeiffer & Son

*Nurseries holding certificates 1919.

†Dealers holding certificates 1919.

LIFE HISTORY OF AN OAK TWIG GIRDLER¹

Agrilus arcuatus Say and var. *torquatus* Lec.

BY A. G. RUGGLES

In August, 1914, my attention was called to the blighting of the oak leaves on the University Farm Campus. The leaves attached to the tips of the twigs wilted and died as if struck by a blight. Upon investigation it was found that the damage was localized, being confined to a comparatively small area around the Twin Cities (St. Paul and Minneapolis) and extending to Stillwater on the St. Croix River.

In studying the damage closely a small buprestid larvae, evidently belonging to the genus *Agrilus*, was found burrowing beneath the bark at the tip of the twigs, causing the death of the part beyond the burrow. In looking up the literature it was found that in California *Agrilus politus* Say² performed a similar operation on a species of oak there. No other reference was found to any other insect behaving in this manner, and hence in our notes we referred to the species as *Agrilus politus*. It was not until June, 1916, that adults were obtained and identified by Dr. Schwartz of the U. S. Bureau of Entomology as *Agrilus arcuatus* Say and variety *torquatus* Lec.

The life history of the insect has been followed very closely for four years, notes being taken at short intervals for the first two years and at longer periods for the last two years. Beyond a doubt it is the worst pest of black oaks discovered in recent years. R. N. Chapman in the Journal of Agricultural Research, Vol. III, No. 4, Jan. 15, 1915, published, "Some Observations on the Life History of *Agrilus bilineatus* Web." *A. bilineatus* and *A. arcuatus* work in the same species of oak—but particularly *Quercus rubra* L. The former attacks the trunk and larger limbs while the latter attacks the tips of the branches and works downward, often cutting off branches eight feet long. These two *Agrilus* species threaten the extermination of the black oak group in the part of Minnesota above indicated, *A. bilineatus* attacking from below and working upward and *A. arcuatus* attacking at the end of the twigs and working downward.

¹ Published, with the approval of the Director, as Paper No. 169 of the Journal Series of the Minnesota Agricultural Experiment Station.

² Cal. Hort. Com. Mo. Bul. Vol III, No. 3, p. 150.

LIFE HISTORY

ADULTS. The first adults of *Agrilus arcuatus* and var. *torquatus* were taken July 1, 1916. From that time until July 27 several hundred were observed. July 7 to 15 seemed to be the week in which they were most abundant. During this time they were observed



Fig. 1. An oak leaf eaten by adults of the oak twig girdler.

feeding and sunning themselves on the leaves. In fact the habits of this species were very similar to those of *A. bilineatus* mentioned by Chapman, with the exception that instead of alighting on the bark to sun themselves they invariably alighted on the leaves. Numerous pairs were seen mating during the week of their greatest abundance, and on July 18, under insectary conditions, a bronze colored male *A. arcuatus* was seen to mate with a copper colored female, *A. arcuatus* var. *torquatus*.

EGGS. The eggs are usually laid singly on the side of the twig near the terminal bud. Sometimes they are laid an inch or more from the terminal bud on last year's wood, as shown in Fig. 3 of Plate I. As soon as laid, the egg spreads out like a little pancake and adheres firmly to the bark. These have been taken, still sticking securely to the bark, two years after being laid. The eggs hatch in about ten days. When first laid they look like a small flattened piece of green gelatine. They soon turn brown and after hatching the shell becomes gray.

LARVAE. First instar. When hatching the young larva makes its way out of the eggshell directly into the bark beneath the egg. Newly hatched larvae were first found July 24. The larvae immediately begin encircling the twig beneath the bark. By August 7 trees all over the cities showed signs of infestation. As the burrowing continued more leaves were cut off. Often the burrowing continued to the junction of the original twig with a larger branch and around the larger branch thus cutting off the nourishment from all the twigs above this burrow. Consequently all the leaves on the upper part of the larger branch soon died. Thus one larva was responsible for the dying of many leaves. During the rest of the month of July and in August and September of the first year the larvae confine themselves to the cambium layer. The burrows at this time were of uniform diameter and the head measurement of the larvae was 0.375 millimeters.

Second instar. In May and June of the next year the larvae still confined themselves to working just under the surface bark. The head measurements at this time averaged 0.47 millimeters.

Third and fourth instars. The larvae were actively at work during July, August and September of the year following hatching, for the most part burrowing in the center of the twigs. To the middle of August the head measurements averaged 0.57 millimeters while after that date they



Fig. 2. The bark on an oak branch removed to show two mature larvae in their burrows.



Fig. 3. An oak tree showing dead limbs killed by the oak twig girdler.

measured 0.75 millimeters, which is the head measurement of the mature larvae.

During October many of the larvae began coming out from the center of the twig and encircling it just beneath the bark. Burrows five and six inches long were often found before this occurred. Often the side branch on which they were working was not long enough and the encircling of the branch would take place on a main branch. Note

Fig. 4, Plate I. The following year, therefore, this larger branch would die. One such branch measured an inch and a half in diameter and was eight and a half feet long.

PUPAE. By May 1 of the second year following egg laying the larvae were found in the prepupal position. By June 1 practically all found were pupae.

As this life history seems rather unusual, the notes of 1914, 1915 and 1916 were supplemented by notes for 1917 and 1918. In August and September, 1918, many red oak trees again showed signs of serious infestation and hence the life history as given is certainly correct for this part of Minnesota.

PARASITES

Parasitism on the larvae of the species was quite evident. At ten different times, the first time just a year after egg laying, parasitic hymenopterous larvae and later, pupae were taken in the burrows of the twig girdler. The reared adults sent to Mr. S. A. Rohwer of the U. S. Bureau of Entomology proved to be a new species of the genus *Tetrastichus*.

CONTROL

Obviously this twig girdler is a difficult insect to combat. The only possible control on large shade trees would be to trim all small dead branches from the trees and burn them with their insect contents. The odd or second year of the infestation these dead twigs stand out very prominently over the tree and can easily be cut. The labor expense, however, in such a project is practically prohibitive. Twenty-five hours were required to prune one red oak, five feet three inches in circumference, thirty-nine feet high, and with a spread of thirty-four feet. The work on this tree was done so successfully that in the next infestation year it was not nearly so badly damaged as others in the neighborhood. To be really effective, all the affected trees in the neighborhood should be pruned. It is possible also that spraying the trees with bordeaux mixture or lime sulphur would act as a preventive as in the experiments with *A. bilineatus*. In any case it is a community problem.

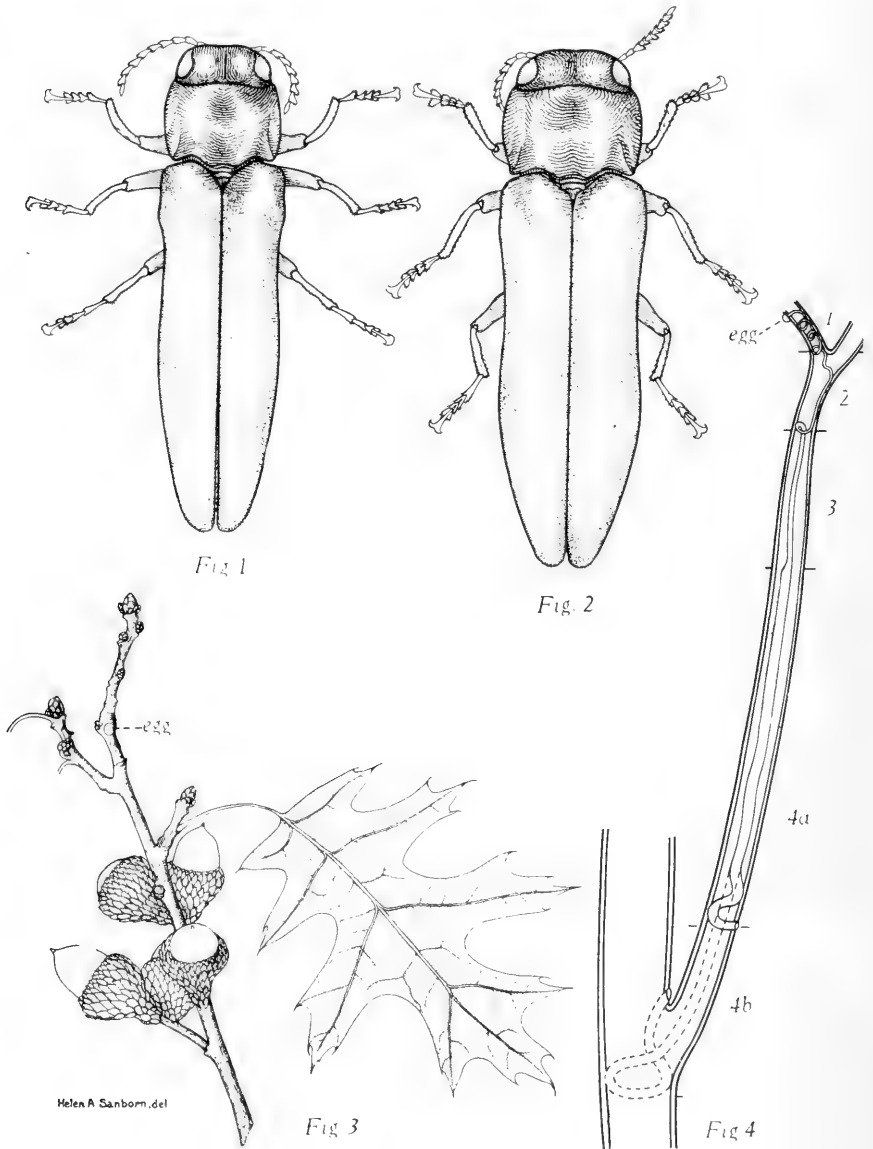


PLATE I

Fig. 1. Adult of *A. arcuatus*. Fig. 2. Adult of *A. arcuatus* var. *torquatus*. Fig. 3. Egg shown in position on an oak twig. Fig. 4. diagrammatic view of a larval burrow. The figures represent the comparative length of instars. 4b shows the way a burrow is often continued.

POTATO SPRAYING IN MINNESOTA¹

BY S. A. GRAHAM

In the past, it has been the custom of the Division of Entomology, in testing insecticides, to carry on the preliminary tests on small plots at University Farm and if these proved satisfactory, to make tests on a larger scale in co-operative experiments with farmers in different parts of the state. For several practical reasons, this system of leaving the final tests to farmers, even with careful supervision, has not proved satisfactory. Since tests on a large scale are absolutely necessary in order that questions may be intelligently and authoritatively answered, and since there was not sufficient available land on or near University Farm for such experiments, it was decided in the spring of 1918 to try a modification of the old co-operative scheme for the potato spraying experiments which promised to avoid most of the difficulties encountered in past seasons.

The greatest difficulty in the past has been to get the materials on the plants at exactly the proper time and in the right way, particularly since most of the experiments were located at some distance from the Station and often in more than one locality. It was also difficult or impossible to get comparative data on a number of different insecticides under the ordinary co-operative agreement. From past experience it seemed advisable to keep the following points in mind.

(1) All spraying and mixing of materials should be done by someone connected with the Experiment Station and not by the farmer. (2) All observations should be made by a man connected with the Experiment Station. (3) The spraying should be done with a standard type of traction spraying machine which should be available at a moment's notice. (4) The spraying experiments should all be located in the same locality, preferably on land owned by a single person, and readily accessible from University Farm.

After some searching, a suitable location was found and the following verbal agreement was made with the owner of the farm.

The owner agreed to:

1. Plow and harrow the soil and plant the potatoes in three foot rows.

¹ Published with the approval of the Director as Paper No. 158 of the Journal Series of the Minnesota Agricultural Experiment Station.

2. Cultivate and perform all necessary operations throughout the season, with the exception of spraying.
3. Allow authorized representatives of the Experiment Station to come onto his property at any time for making observations, spraying or collecting.
4. Furnish a team for use in spraying, whenever it was deemed necessary by the man in charge of the experiments.
5. Furnish water and a place for mixing materials.
6. Furnish a dry storage place for the insecticides.
7. Keep the man in charge of the experiment informed as to the dates when digging was contemplated, so that he might be present to record the yield.

The Experiment Station agreed to:

1. Furnish a suitable machine for the work and keep it in repair.
2. Furnish all insecticides and other spray materials.
3. Mix and apply the materials when necessary.
4. Use no materials on a large scale except such as had been given preliminary tests and had shown promise of success.
5. Keep all records and be responsible for all observations.

This agreement fixed the responsibility and made clear to each party his duties in connection with the experiment.

Under the old system of co-operation, it was impossible to run a series of experiments on the same farm, using a variety of insecticides side by side, since the farmer very naturally was unwilling to spend the extra time and trouble in spraying that such a set would necessitate. Since it is impossible to accurately compare results when plots are on different farms or even more difficult when they are located in different counties, the confining of all the potato spraying experiments to one farm was exceedingly advantageous.

POTATO INSECTS OCCURRING ON THE PLOTS

The plots selected for the work were well supplied with insect pests, altho no disastrous outbreak of any species was threatened. The adult colorado potato beetle, *Leptinotarsa decemlineata* Say, was very abundant in the spring. The potato flea beetles, *Eptatrix cucumeris* Harr., and the leaf-hoppers, *Empoasca mali* Le Baron, were the other primary pests. In addition to these insects which were of primary importance, the tarnished plant bug, *Lygus pratensis* Linn., and several other bugs were common.

MATERIALS TESTED

The stomach poisons tested were:

1. Lead arsenate.
2. Zinc arsenite.
3. Calcium arsenate.
4. Paris green.

Each of these poisons was applied with and without bordeaux mixture.

The contact insecticides used were:

1. Nicofume.
2. Black leaf 40.
3. Nicofume oleate.

These materials were all applied with a four row traction sprayer equipped with a "bordeaux" boom which sprayed from the sides as well as from above, using three large chambered nozzles to the row. The pressure was kept at about seventy-five pounds. At this pressure fifty gallons of liquid was required to cover an acre.

ARRANGEMENT OF THE PLOTS

Three fields having a total acreage of about twenty acres were available for this experiment. A little less than one half of the total area was planted with Early Ohios and the remainder with Rural New Yorkers. Since early potatoes as a rule seem to suffer more seriously from insect attacks than the later varieties, and since the Early Ohios were planted all together on a fairly uniform piece of ground, these were selected for the most intensive work. In the case of both the early and late varieties, the fields were divided into plots. These plots varied somewhat in size according to convenience. Each material was applied to two or more plots in the case of both early and late varieties, so as to eliminate as far as possible error due to soil variation.

STOMACH POISONS

The first set of arsenical sprays was applied to the early potatoes and to the late potatoes adjoining them on June 13 and 14. At this time, the plants in the early plots were eight inches high while those on the late plots were about six inches high. The adult potato beetles had been present on the plants for a week or more. Eggs were observed for the first time four days previous to spraying. None of the eggs were observed to have hatched at the time the first spray was applied, altho it is possible that some newly hatched larvae had

escaped observation. At this time the potato flea beetles were quite abundant and it was primarily for this insect that the bordeaux mixture was used. The water used in all the experiments was a natural soft water from lakes nearby. Everything that went into the tank, including the water, was poured through a fine wire strainer. As a result of this care, combined with the fact that large chambered nozzles were used, and that the machine was washed out after each day's work, practically all nozzle trouble was eliminated.

The weather at the time of spraying was dry and clear with a hot sun. There was a light breeze from the west and south. The weather continued dry for several weeks following spraying so that the poisons were not washed off the plants, thus giving opportunity for maximum efficiency of all the poisons used. Under these ideal conditions, the effects of the various poisons on the potato beetles were remarkably uniform. Before spraying, the adult beetles were abundant in all parts of the field, and plants on which eggs were found averaged seventeen to each row. One week after spraying the adult beetles were remarkably few in number and less than three plants in each row showed injury from larvae. These rows were about sixty rods long.

Thus it would appear that all four of the poisons tested in this experiment were equally effective under ideal conditions, so far as the potato beetle was concerned. The dilutions used were two pounds to the acre, or four pounds to each one hundred gallons of liquid, in the case of lead arsenate, calcium arsenate, and zinc arsenite, and one pound to the acre, or two pounds to one hundred gallons of liquid in the case of paris green. Each of these materials was applied both with and without 4-4-50 bordeaux mixture. All of these materials, including bordeaux mixture at the dilutions used, appeared ineffective as a poison or deterrent for the flea beetle adults.

The second spray was applied July 1. At this time the vines had doubled in size, leaving a large unpoisoned surface on every plant. There were, however, so few potato beetles present that it is probable the average grower would have considered the field "bug free," and would not have deemed spraying necessary at this time. There were enough beetles present, however, to form the nucleus of a considerable infestation if permitted opportunity to increase unchecked. This possibility was illustrated by a field on another farm just across a railroad track from the experimental plots. This field was later quite badly injured by beetles altho it was comparatively free at the time the above observations were made. Materials were used at the same dilution for this as for the first spraying. The weather was warm and dry, making conditions again ideal for the maximum efficiency of the

sprays. One week after this spraying, it was difficult to find any plants on which the beetles were working, except a few at the edges toward adjoining infested potato fields. The late potatoes adjoining the early variety and a small block of a little more than an acre, designated as block No. 2, were also sprayed at this time. The beetles on these plots of late potatoes were even less abundant than on the early plots and the control was almost perfect in each case.

The remaining block, designated as No. 3, was not sprayed for the first time until June 29. At the time of spraying a few larvae had hatched but for the most part, the eggs were still unhatched. Adults were abundant. On this block three poisons, paris green, lead arsenate, and zinc arsenite were used at the same rates as in block 1 with almost perfect control in each case. This block was sprayed again on July 23, altho the beetles were not numerous enough at that time to make the treatment commercially profitable. Those present, however, were well grown and so a heavy dose of two pounds of lead arsenate and one pound of paris green per acre was used. This spraying almost entirely exterminated the beetles in this field.

From this series of experiments it is evident that lead arsenate, paris green, calcium arsenate and zinc arsenite are equally effective against the colorado potato beetle under favorable conditions of spraying. Since this is true, the factors which should determine the most desirable of these insecticides to use in potato spraying are power of adherence and cost. Since it is a very difficult matter to determine the comparative power of adherence of insecticides in the field, this was determined by laboratory experiments.

POWER OF ADHERENCE

In the determination of the comparative power of adherence of arsenicals, considerable difficulty was encountered in devising satisfactory methods of measurement. Two satisfactory methods were finally worked out. Both of these methods were used, each serving as a check on the other. The first was as follows. The materials were mixed with water as for field spraying and a measured amount of each was placed on clean microscopic slides and allowed to flow evenly over the entire surface. These slides were then dried at room temperature in a dust-proof cabinet for 48 hours, after which they were carefully weighed. They were then fastened in a vertical position and sprayed with water delivered at a uniform pressure from a spray nozzle. Each slide was placed in the same position and the nozzle was clamped in place so that each

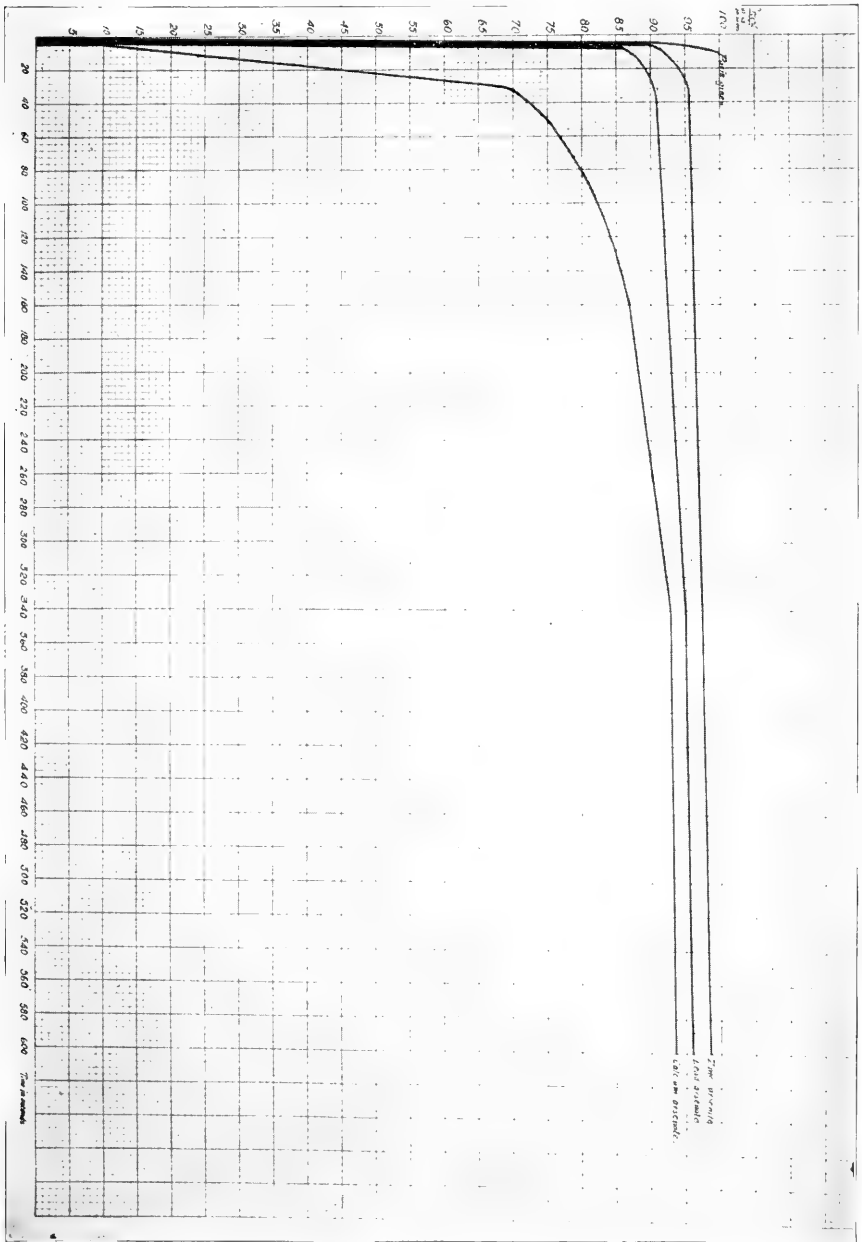


Fig. 4. Curves illustrating the comparative adhesive power of lead arsenate, zinc arsenite, calcium arsenate and paris green.

slide received as nearly as possible the same intensity of spray. The slides were washed for from two to six hundred seconds, dried and again weighed, cleaned and weighed a third time. From the figures thus obtained, the percentage of the material washed from the slides in a given time was computed and a curve constructed for each material. At least 5 points were determined on each curve and each point was the average of five slides washed for the same length of time.

The results of this series of experiments showed that of the insecticides used, paris green washed from the slides most readily, 100 per cent being washed off in ten seconds. The other three materials resisted washing much better, zinc arsenite losing about 98 per cent, lead arsenate 91 per cent and calcium arsenate 88 per cent in 600 seconds.

These results showed that of the four materials used, calcium arsenate has the greatest power of adherence to glass. Whether or not the same ratio would hold good on leaves, was open to doubt. To check this point the second method was used. Geranium leaves were used in this series of experiments.

The materials were mixed with water as before and placed by means of a medicine dropper upon the leaves. A measured amount of the liquid containing the arsenical was placed on each leaf, being careful that none ran off. In this way approximately 4 milligrams of the desired arsenical was deposited on each leaf. Ten leaves were used for each material. After drying, these leaves were washed for 5 minutes under a uniform spray. Later they were digested with sulphuric acid and their arsenic content determined by the Gutzeit method.² The results are shown in Table 1, tabulated in terms of the arsenicals used.

TABLE I

	Milligrams left after washing	Percent washed off	Coefficient of adhesion to ge- ranium leaves
Calcium arsenate	3.0	25	74
Lead arsenate	2.55	37	62
Zinc arsenite	2.00	50	50
Paris green	0.04	99	1

The range of experimental error is greater in using leaves than in using glass slides, but the results from these two sets of experiments are so comparable that it is safe to assume that the same ratio of adhesion holds good in each case.

² Scott—Methods of Chemical Analysis.

COMPARATIVE COST

The cost of an arsenical cannot always be accurately judged by its price per pound since the different materials used as insecticides do not contain the same proportion of arsenic. Table II shows the approximate proportion of arsenic contained in the four poisons treated in this article.

TABLE II

	Arsenic content in terms of As_2O_5 Per cent
Calcium arsenate	42-52
Lead arsenate	30
Zinc arsenite	40
Paris green	58

From this table it is seen that paris green contains almost twice as much arsenic as lead arsenate. Thus it follows that to do the same work, lead arsenate must be used at almost double the strength of paris green. If paris green sells at 70 cents a pound and lead arsenate at 35 cents, the cost of the arsenic would be about the same in each case, altho the arsenic in paris green would not be worth as much as that in lead arsenate, owing to the difference in power of adhesion. The same comparison may be made between lead arsenate and calcium arsenate or zinc arsenite.

Since calcium arsenate usually costs the farmer about 5 cents less per pound than lead arsenate, it is by far the cheapest arsenical on the market. When its high power of adherence is also considered it stands far above the other materials for potato spraying.

There is, however, one very serious objection to the use of calcium arsenate for general spraying. Calcium arsenate as sold for insecticidal use has a tendency to burn tender foliage, due largely to soluble arsenic contained in it. This difficulty will undoubtedly be overcome eventually. It is perfectly safe, however, to use calcium arsenate on potato vines, since there is not so much danger of burning as with paris green.

CONTACT INSECTICIDES

The only contact insecticides used in this series of experiments were nicotine compounds applied both with and without soap. These were applied July 9, when the leaf hopper nymphs were most abundant, since it was thought that at this time they would be more easily hit than when in the adult stage. The results of the field experiments were not by any means conclusive in themselves, but when considered

together with results in the laboratory, they throw some light on the problem of leaf hopper control. The results may be tabulated as follows: The numbers in the per cent killed column represent a comparison of the number of hoppers on the sprayed plots with the number on check plots. An estimate of the average number of hoppers per plant was made by counting those on one plant in each thirty feet of each row and averaging for the plot.

TABLE III

	Per cent killed
1. "Nicofume" 1-500 and soap 1 lb. to 50 gal.....	65
2. "Nicofume" 1-500 without soap.....	17
3. Nicofume oleate 1-500	3
4. Nicofume oleate 1-500	4
5. "Black leaf 40" 1-500 and soap 1 lb. to 50 gal.....	13
6. "Black leaf 40" 1-500 without soap.....	6

From the above table it is evident that nicofume with soap was the only material giving even partially satisfactory control in the field. Since those results were not sufficiently clear cut to form a safe basis for any conclusions, it was deemed advisable to test the same materials under carefully controlled laboratory conditions to determine their comparative toxicity to leaf hoppers. On account of the difficulty of handling the adults, well developed nymphs were used. Leaves, each with six or more hoppers, were placed in individual vials closed with cheese cloth. As soon as possible after collection, each leaf was removed from the vial with the leaf hoppers clinging to it, quickly sprayed with the desired material, and placed in a small cheesecloth cage. A few leaf hoppers were, of course, lost in this operation, but enough remained for the purpose of the experiment. The spray dried from the leaves very quickly in the cheesecloth cages thus imitating outdoor conditions as nearly as possible. The morning following treatment the cages were opened and the results of the spraying were recorded. As a check, leaf hoppers were sprayed with clear water and placed in cheesecloth cages. Without exception, 100 per cent survived this water treatment. The nicotine compounds were all used at the rate of one part to 500 parts of water. In order to determine the influence of the kind of water used in mixing the spray materials upon the effectiveness of the spray, each material was used with distilled water, water from Parker's Lake, and tap water. The results may be tabulated as follows:

TABLE IV

Material	Per cent killed		
	Dist. water	Parker's L. water	Tap water
Nicofume oleate	75	74	50
Nicofume oleate and soap 1 lb. to 50 gal.	96	100	97
Nicofume oleate with 1% kerosene emulsified	67	73	59
"Nicofume"	48	61	75
"Nicofume" and soap 1 lb. to 50 gal.	100	100	96
"Nicofume" and soap 1 lb. to 100 gal.	80	91	79
"Black leaf 40"	58	41	48
"Black leaf 40" and soap 1 lb. to 100 gal.	99
"Black leaf 40" and soap 1 lb. to 50 gal.	100	96	100

From these results it would appear that both nicofume and black leaf 40 with soap are effective in killing leaf hoppers, but it is also evident that the insects must be thoroly wet with the spray if the results are to be most effective. The fact that such a small proportion of the leaf hoppers was killed in the field experiments was probably due to the fact that many of the insects were not hit. Altho three nozzles were used to each row, the under side of the leaves was not at all thoroly wet. Thus the fault would seem to lie with the mechanics of application rather than with the insecticide.

From observations in the field and in the laboratory the amount of nicotine necessary to kill a leaf hopper in either nymphal or adult stages, is certainly not greater than that required to kill the potato aphid, since individual aphids accidentally included in experiments have frequently come through alive, while the leaf hoppers subjected to the same treatment have all been dead. It seems almost certain, therefore, that if a tobacco extract *with soap* can be applied in such a way as to wet the leaf hoppers thoroly it will be effective in destroying these insects. Soap, however, seems essential to the successful use of these materials, giving the spray liquid the proper physical characteristics for maximum effectiveness,³ as well as adding a toxic action of its own. For maximum effectiveness, this would necessitate the separate application of the contact insecticide, or its application in mixture with other materials not of a strongly alkaline nature, since a strong alkali would destroy the soap, thus reducing the value of the tobacco extract. This would preclude the use of these extracts with bordeaux mixture. On the other hand, they could be used with lead arsenate, paris green, or zinc arsenite; since the soap solution would not be destroyed by these compounds. The addition of soap

³ Moore, Wm. and Graham, S. A. — Physical Properties Governing the Efficacy of Contact Insecticides. Jour. of Agric. Res. Vol. XIII No. 11, June 1918.

would keep the arsenical in suspension for a longer time than would otherwise be the case,⁴ would help to distribute the material over the leaves,³ and would possibly improve its sticking power. It is doubtful, however, if soap could be used with calcium arsenate, owing to the excess of lime usually present in that material.

In the field experiments this season, the spray for leaf hoppers was applied when the nymphs were most abundant. It was thought that this would be the best time since the insects would then be less able to jump and fly ahead of the machine. This spraying would probably have proved effective if the under side of the leaves could have been thoroly wet with the spray. But, as was pointed out before, this was impossible with the machinery used. Delaying spraying until the nymphs are most abundant has the decided disadvantage of withholding the treatment until a large part of the leaf hopper injury has been done. These two facts coupled with observations of leaf hopper adults flying into the spray and falling to the ground in a stupified condition suggests the possibility of spraying when the adults first appear on the vines in the spring and driving them through the spray.

In summing up the possibilities for satisfactory leaf hopper control, it appears that the tobacco extracts when used with soap are effective in destroying these insects. The present mechanical methods of applying these materials, however, are faulty and future efforts should be directed toward improvement along this line.

$$^4 \text{ Stokes law } - V = \frac{2R^2(S - S')g}{9N}$$

V=Velocity of settling. S=Specific gravity of solid. S'=Specific gravity of the liquid. R=Radius of particles. g=Gravity. N=Viscosity of liquid.

THE CARPENTER ANT AS A DESTROYER OF SOUND WOOD*

BY S. A. GRAHAM

The carpenter ant, *Camponotus pennsylvanicus* Degeer and its variety *ferrugineus* Fab. have been universally referred to in entomological literature as workers in decaying wood, but apparently never have been regarded as pests of sound trees or timbers. Wheeler¹ mentions the species repeatedly as a dweller in rotten and rotting wood but never as attacking sound material. Marlatt² states that "it normally constructs its galleries in logs and dead trees in the forests, but not infrequently, in the case of wooden houses, and especially those near forested tracts, gains access through porch beams or the underpinning of such houses and mines and weakens the supporting timbers and other woodwork. As a rule, it affects only decaying portions of the wood, but sometimes carries its channels into the sound wood." Comstock³ also refers to this species as working in rotten wood.

Until recently the observations of the author have tended to confirm the facts as set forth in literature, and so when reports were received stating that ants were responsible for a large amount of damage to standing white cedar in Minnesota, it was believed probable that this ant injury was only secondary to heart rot and that the ants were not primarily injurious. A trip through the cedar districts of the state showed, however, that this assumption was erroneous and that carpenter ants were frequently found working in the solid heart wood of living white cedars, causing extensive injury.

It seemed that this injury to living cedar has been regarded by the cedar dealers as a necessary evil and except for culling heavily ant injured poles, little thought has been given it. There has been no effort to reduce the loss occasioned by this pest on the part of the cedar men and perhaps for this reason the problem has never before come to the attention of entomologists. It is nevertheless an important problem for the forest entomologist and will become more important with the increasing scarcity of white cedar of pole size.

*Published with the approval of the Director as Paper No. 157 of the Journal Series of the Minnesota Agricultural Experiment Station.

¹ Wheeler—Ants: Their Structure, Development and Behavior (1910).

² Marlatt—House Ants: Kinds and Methods of Control U. S. D. A. Farmers Bulletin 740 (1916).

³ Comstock, A Manual for the Study of Insects (1907).

METHOD OF WORK

So far as observed, the carpenter ant never attacks a perfectly sound tree, but always gains entrance through a wound or a decayed spot. At first thought it would seem that this habit would result in a scarcity of suitable nesting places and that the spread of the ants would be limited by this factor to such an extent as to make their injury negligible. This would probably be true if it were not for the fact that in Minnesota less than five per cent of the white cedar of pole size is sound, and many trees which appear sound on the stump have injured or diseased areas near the ground. Thus almost every cedar of pole size is a fit subject for ant attack.

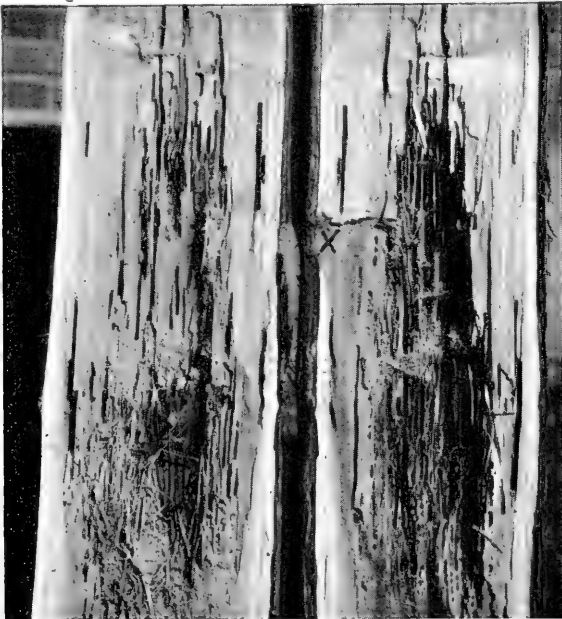


Fig. 5. Ant nest in cedar butt. X shows the position of a window.

After the colony has been established in a tree, the ants usually work well above the rotten area into the sound heart wood, honeycombing the tree with longitudinal galleries until there is often only a thin shell of solid wood around the nest. Where the main nest is located, they cut openings to the outside, frequently following out a knot, through which the sawdust may be cast and through which the inhabitants may pass to and from the nest. These openings, which are known in the woods as "windows," make it easy to locate the position of the nest without cutting into a tree, since the nest never extends far above the topmost window.

The height at which the nests are built varies greatly but they are usually located within six feet of the ground. They may, however, be occasionally built high in the trunk. As a rule, the ants gain entrance to a tree at a point near the base, sometimes even below the ground level, starting either in the trunk or in a large root. Occasionally entrance may be gained through a knot-hole in the trunk. This latter is usually the case when the nest is located at a considerable distance above the ground.



Fig. 6. Window opening to the outside.

EXTENT OF INFESTATION

The percentage of ant infested cedars varies with the conditions under which the trees are growing. Trees growing in the swamps are much less heavily infested than trees growing on higher ground. Counts made on plots laid out under various conditions showed this to hold true in every locality studied. A very good example of this difference was shown in a series of plots located near Blackduck, Min-

nesota. This was a series of one tenth acre plots running from high land through a small swamp and up to the top of a ridge on the opposite side. Plot number one was located on dry land just at the edge of the swamp and showed an infestation of sixty per cent. Plot number two was partly in the swamp and showed an infestation of twenty-three per cent. Plot number three was all in the swamp and showed an infestation of twenty-three per cent. Plot number four was on the dry land sloping up from the swamp with an infestation of seventy-two per cent. The next three



Fig. 7. Ant nest in cedar showing ants.

plots, numbers six, seven and eight were high on the ridge and showed a sharp reduction in ant infestation to twenty-one, twenty-four and thirty-eight per cent respectively. This was the only locality where a sharp reduction of infestation on a ridge was observed. It was, however, by far the highest ridge on which cedar was studied and so no other plots were comparable to these. In addition to the high elevation, the cedar on this ridge was mixed with other species of trees, which may have had some influence on the extent of ant infestation. The high infestation on the strip of dry land bordering the swamp, which is shown so clearly in this series of plots, held true in every locality. These observations in the field correspond with the observa-

tions of men in the cedar yards who say that it is much less common to find ants in the heavy, sour butts from the swamps than in the light upland cedar.

In every locality where studies were made, the percentage of trees infested averaged very nearly the same as that at Blackduck, which would make the average infestation for the state run between fifteen and twenty-five per cent in the swamps and from forty to seventy per cent on the higher land. Altho the factors resulting in the heaviest infestation occurring on the dry land just out of the swamp have not



Fig. 8. Three trees left "hanging" because they showed ant injury on the butt.

been determined, there are several possible theories. The first is that since the ants are land animals, they prefer the dry ground to the swamp, but this scarcely seems a satisfactory explanation since it would be perfectly possible for the ants to make their way about in the swamps without getting wet at practically any time of the year. It is possible, however, that the wet condition of the ground would tend to increase the moisture in the nests, making them less comfortable and increasing the danger of an epidemic of some fungous parasite in the colony.

The percentage of trees with heart rot is greater on the dry ground than in the swamp. This factor may have considerable influence, since



Fig. 9. Tree which showed ant injury on the butt, butted off unnecessarily leaving a stick too short for a pole. Left in the woods although it would have made several good posts.



Fig. 10. Illustrating the custom of first cutting a pole to length and then butting off for defect, a practice which results in much waste. Two feet from the butt of this tree would have cleared it.

the heart rot would make it easier for the ants to gain entrance into the trees. The difference in texture of the wood in swamp and high-land cedar also may have its influence, since the wood of the swamp cedars is much heavier and closer grained than that grown on the higher land. All these factors probably have their influence in limiting the extent of infestation in the swamps.

Since such a large proportion of ant infested cedar trees are also hollowed more or less by heart rot, many poles which must be trimmed for ant injury would necessarily have to be trimmed for rot even though no ants were present. When it is remembered, however, that the ants as a rule work above the rot into the solid wood, it is evident that they increase considerably the length which must be cut from the butt. From measurements made in the woods, it is estimated that in the swamps there is an unavoidable loss of about three feet from the butt of every ant infested cedar, and on the higher ground, where the heart rot runs higher, the average loss runs nearly six feet. In either case, allowing for heart rot it is safe to say that ants were responsible for an average loss of at least two feet for each infested tree.

While there is an immense amount of unavoidable loss due to ant injury, the loss occasioned by careless butting is still greater. This is often due to the fact that many of the cedar makers do not know how to locate accurately the ant nest, so as to insure cutting just above it. Frequently a man will get only a 20-foot pole out of a tree which should have made a 25- or 30-foot pole if properly cut. Sometimes a man will hack into a pole every two feet until he finds it sound, thus destroying any value which the butt may have had. It may occasionally be necessary to follow up rot in this way, but where ants are in a stick their nest is practically always above the rot and it is only necessary to look for the topmost window to tell where to make the cut with the least amount of loss. Therefore the first thing to do in making a pole from an ant infested tree, is to look for the windows and then measure up the pole and cut to the best advantage. The usual method seems to be to make the pole and then begin butting off. There is also a great deal of good material in the butts which could be used for posts, slats or other purposes where they can be handled to advantage. Butting off the poles in the yard might help save this loss in many cases.

It is the custom of most of the cedar men to cull very heavily for ant injury. This custom has brought about a condition which results in the absolute loss of large quantities of merchantable material as the cedar makers will not spend their time on pieces which they think may



Fig. 11. Poles showing both rot and ant injury.



Fig. 12. Posts showing both rot and ant injury on the butts.

be culled. As a result anything that looks like a cull is usually left in the woods even though it may contain a considerable amount of good material.

RECOMMENDATIONS

So far as protection from ant attack of cedar trees in the woods is concerned, nothing can be recommended at the present time. It is possible, however, to save an immense amount of merchantable material by closer utilization of ant infested cedar, combined with intelligent trimming of poles. Since it is possible to tell approximately where a pole must be cut to clear it of serious ant injury by simply looking for the topmost window, it seems unnecessary for the buyers to cull so heavily for this defect as is the general rule at present. The grading rules regarding this injury should be made more lenient, so that a cedar maker can be reasonably certain to receive for a pole what it is really worth. Dealers should accept ant poles at their full value provided the injury is not such as to weaken the pole. If a pole shows ant work on no more than 10 per cent of the butt surface, and has no windows more than one foot above the butt, the pole should not be considered weakened.

Until something of this sort is done it is certain that the cedar makers will continue to leave in the woods many valuable poles and much good post material.

SUMMARY

1. Large black ants commonly known as carpenter ants are doing considerable damage to standing white cedar in Minnesota, at least twenty per cent of the trees cut showing ant injury on the stump.
2. The colonies are started in a wound, knot hole, or decayed spot, usually near the butt of the tree.
3. The ants hollow out a nest in the heart of the tree sometimes leaving only a thin shell of wood around it, thus seriously weakening the tree at that point.
4. From this nest the ants cut openings to the outside called windows and to locate a nest it is only necessary to look for the windows.
5. Much unavoidable loss is occasioned by ant injury, but there is also an immense amount of loss through careless cutting of poles.
6. Culling heavily for ant injury has meant leaving in the woods anything that looks suspiciously like a cull.
7. The grading rules regarding ant injury should be made more lenient so as to encourage more careful trimming of ant infested poles.

DROSOPHILA IN BOTTLED CERTIFIED MILK¹

BY W. M. A. RILEY

The finding of conspicuous extraneous matter in the household milk supply is never very appetizing. When such material is found in certified milk in bottles bearing the label, "This milk is certified by your State Board of Health," the customer is quite likely to feel and to express an especial resentment. An instance of this nature which recently came to my attention proved of much entomological interest and led to a study which revealed that such cases are not so rare as might be suspected from the fact that they do not seem to have been recorded in our literature.

Early in September there was submitted to me a quart bottle of milk which bore scattered along the sides some thirty small seed-like specks about $2\frac{1}{2}$ mm. in length. Altho these were minute, they stood out very conspicuously against the white background of the milk, as is evident from the photograph reproduced herewith. In general appearance they resemble grass—or "hay"—seed and are often so interpreted by workers in the dairies and distributing stations. More detailed examination revealed that the "seeds" were the puparia of a fly of the genus *Drosophila*. Attempts to secure adults were made, but for reasons which will appear later, these were unsuccessful.

The puparium does not correspond to any of the few that have been accurately described. It is hoped that the accompanying figure and the following notes may serve to definitely identify the species when more is known concerning the life histories of the group.

The puparium is of a light straw color, $2\frac{1}{2}$ to 3 mm. in length by 0.8 mm. in width, strongly convex on the dorsal surface, but slightly so on the ventral surface. The segmental limits and the cuticular appendages are well shown in the figure. The pharyngeal skeleton of the larva is retained as a conspicuous black mass near the anterior end of the puparium. The dorso-cephalic region is flattened and from it project the two digitate pupal spiracles. The basal portion of these processes measures some 200 microns in length by 50 microns in diameter and bears 11 filiform processes measuring up to 300 microns in length.


11 50
a 2

¹Published with the approval of the Director as Paper No. 145, of the Journal Series of the Minnesota Agricultural Experiment Station.

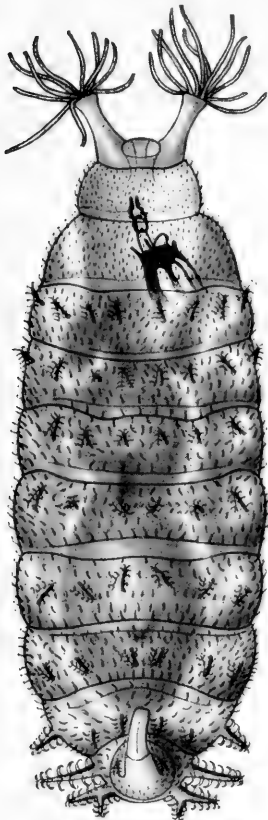


Fig. 13. Puparium of *Drosophila*.

At the posterior end is a pair of spiracles which represent the single ones of the larva in *Drosophila ampelophila* and *D. amoena*, whose life histories, thanks to the studies of Professor Comstock in 1882, are the best known. These spiracles are borne upon a pair of clearly separated tubercles. In the species under consideration, however, they are carried on the distal end of a single caudo-dorsal process, as is shown by the illustration.

Naturally, both the customer and the milk distributing company were anxious to know the nature and the source of the infestation, while the health authorities were interested in the possibilities of other gross, tho less conspicuous, contamination. In order to investigate conditions five of the large distributing companies of the city were visited. In each place I found that the occurrence of these peculiar "seeds" or "bugs" was well known. All agreed that they were most commonly found earlier in the season tho two samples were obtained at the time (September 30) and at another place they had been observed that day but discarded. Two more infested bottles were

obtained the next day. Thus it would appear that the phenomenon is not a rare one.

It developed, as was to be expected from the habits and length of the life cycle of the flies, that the contamination was in bottles which had been returned to the central stations infested. Lying about homes and especially about restaurants and saloons, they had served to attract the flies which oviposited in the souring milk. It was very significant that one proprietor noticed the difficulty most frequently in Bulgarian buttermilk bottles. That this was not the only source was evident from the fact that the difficulty was observed in dairies that did not deal in buttermilk, and that two of the samples sent were in cream bottles.

Judging from known life histories, the hatching larvae from the first deposited eggs would be pupating within a week. The pupae are sufficiently transparent to escape careless inspection and adhere so tight-

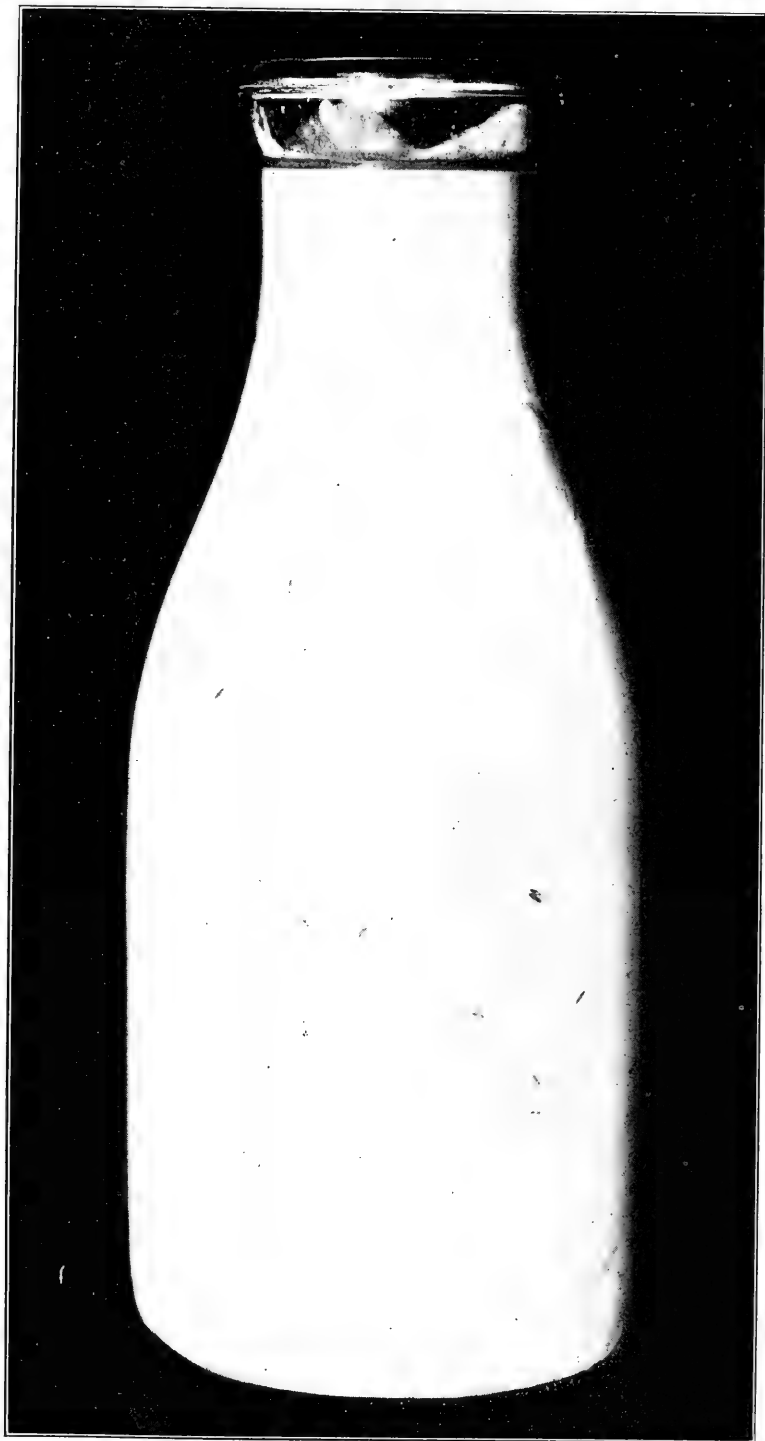


Fig. 14. Puparia of *Drosophila* attached to inside of milk bottle.

ly to the sides of the bottle that even thoro washing at the dairy fails to remove them. When the bottles are filled, the insects stand out so prominently that they are usually noted by the inspector and discarded, but an occasional one gets to the wagons and is delivered to a customer.

There can be no doubt that in a properly managed dairy the pupae are not only killed but are rendered thoroly innocuous. The bottles are treated with a hot, almost boiling, caustic solution, washed in hot water and come through the washing machine so hot that they cannot be handled with comfort. In this condition there is nothing about them to attract flies and the further process of bottling and sealing affords no opportunity or inducement for ovipositing. Even if eggs could be introduced at this stage the milk would be disposed of before there was any opportunity for the development of the later stages of the insect.

In view of the known habits of the pomace flies there is no reason to suppose that the forms attracted to sour milk would necessarily be of one species. In a cream bottle secured subsequent to the inspection trip there occurred along with the above described species a preponderance of a considerably larger type of puparium. These measured 5 mm. in length, nearly twice that of the other species, and were of a bright brown color. The caudal spiracles were borne on paired tubercles.

In spite of an extensive search I failed to find in the entomological literature any mention of *Drosophila* breeding in milk. The nearest approach is an untraced reference to their occurring in rancid butter. However, the phenomenon has not completely escaped attention. In the *Zeitschrift für Fleisch und Milchhygiene*, 1913, Vol. XXIII, p. 252-253, Otto Fettick reports a similar case which came to his attention. The specimens were in bottled milk which had been obtained from a large distributing station. Tho it is obvious from his description that he was likewise dealing with puparia, he regarded them as larvae of *Drosophila* or a related genus. He was unable to breed the adults and concluded that since no motion was to be detected in the "larvae" they were dead when received.

Fettick speculates as to the source of the contamination and dwells especially upon the sanitary aspects of the question. He says:

"Fly larvae of this genus find suitable conditions for living in shallow, easily warmed, foul water, containing organic matter, as well as in moist, fermenting substances. They cannot live in pure spring water suitable for drinking, or in tap water, into which, moreover, they cannot get on account of their size (! R.). It is, therefore, highly probable that the larvae found in milk reached it at the producing station probably through washing and rinsing of the cans or milk

vessels with unclean and therefore insanitary water. It is, however, not to be denied that the flies may have gotten into the dirty bottles containing a residuum of milk before they were filled. For this reason the milk in the bottle must be regarded as questionable from a hygienic viewpoint."

It was this view which first impressed itself upon me. A more careful examination of conditions has convinced me that it is incorrect and that the presence of the puparium is no index of the thoroughness of the sterilizing process which the bottles undergo before they are filled. Indeed it would seem clear that, as in my experience, the failure of Fettick to rear the flies was due to the fact that the pupae had been killed by the washing process to which the bottles were subjected.

It must not be overlooked that the presence of such organisms is but a readily visible illustration of the gross contamination which may occur in milk bottles in homes and in business places. To one who has seen conditions it is almost inconceivable that a housekeeper should be willing to return bottles in the filthy condition in which they are sometimes received by the dairies. It certainly affords argument for the enforcement of ordinances requiring milk bottles to be washed when emptied.

My thanks are due to Mrs. Helen Sanborn Chapman for the faithful manner in which she has executed the accompanying drawing of the puparium. I am also obligated to Mr. C. K. Linton, of the Minneapolis City Health Department, who first brought this subject to my attention and whose co-operation made it possible for me to study conditions in the local distributing stations.

CONTRIBUTION TO KNOWLEDGE OF THE TRIBES AND HIGHER GROUPS OF THE FAMILY APHIDIDAE (HOMOPTERA)

BY O. W. OESTLUND

Aphids are of considerable importance from an economic standpoint as all of them feed on the juices of plants. Their identification and placing in a natural system of classification have become exceedingly difficult of late on account of the great number of new genera and species made known. The older groups, to which we had become accustomed, are much overloaded and their demarcations proportionally indistinct. The following paper is an attempt to bring this side of the question up to date.

Several attempts have been made to arrange the family in natural tribes and higher groups. The first serious attempt was made by Koch, but as no characteristics were published, only the names with included genera, it has remained practically unnoticed. Passerini's classification has been followed by most writers up to very recent time. Mordwilko's arrangement is better and is gradually replacing that of Passerini. Important additions have still later been made by Tullgren, Wilson, and others.

In the following, the attempt has been to give proportionate consideration to the historical, morphological, and biological aspects as necessary foundations toward a natural classification, which of necessity is largely biological and historical, and not alone morphological.

FAMILY APHIDIDAE

- Linnaeus, 1758, Syst. Nat. Ed. X. Sub *Aphis* (genus).
- Latreille, 1807, Gen. Crust. Vol. 3. Sub *Aphidii* (family).
- Leach, 1815, Encyclop. Vol. 9. Sub *Aphidae* (family).
- Burmeister, 1835, Handb. Entom. Vol. 2 Sub *Aphidina* (family).
- Zetterstedt, 1840, Ins. Lap. Part 1. Sub *Aphidiae* (family).
- Amyot et Serville, 1843. Hemipt. Sub *Gradipedes* (family).
- Rondani, 1848, Nouv. Ann. Bologna Vol. 9. Sub *Aphidinae* (family).
- Harris, 1852. Treatise Ed. 2. Sub *Aphididae* (family).

Early writers refer to members of the present family under such common terms as *pediculus*, *Blat-laus*, *pucceron*, *plant-louse* etc., which varied with the language and the country. Linnaeus^d(1758) named all forms known to him according to the binomial system under the generic term *Aphis*. Latreille (1807) united the genus *Aphis* with *Thrips* and *Aleyrodes* under the family name *Aphidii*. Leach (1815)

corrected this to Aphidae, the term generally accepted by British authors. Burmeister (1835) used the term Aphidina, which has been extensively followed by authors on the continent. Other terms proposed but not generally accepted are: Aphidiae, Zetterstedt (1840); Gradipedes, Amyot et Serville (1843); Aphidinae, Rondani (1848). Harris (1852) used the form Aphididae as now accepted by the best writers.

Morphological characters. Much importance has been given to the form of the head in the classification of aphids. Three types or lines of modifications may be distinguished. First, the transverse (generalized), in which the head is broader than long, the distance between the antennae is wide and the frontal margin straight; this form is characteristic of the Lachnina. Second, the subquadrate (aphidian), in which the head is narrowed anteriorly and produced as a pair of frontal tubercles on which the antennae are situated; the frontal margin is concave or emarginated. Third, the reduced (pemphigian), correlated with the reduction of the antennae and the eyes in the gall and underground forms of the Pemphiginae. The frontal margin in this type is usually convex. The family is unique, as far as known, in the presence of three types of insect eyes at the same time in the alate forms: the larval eyes which persist through life as the ocular tubercles with the compound eyes and the dorsal ocelli of the alate forms. The antennae are typically composed of six segments. The first two segments are short and broad, and usually devoid of sense structures. The following segments are more slender and known as the flagellum, and always provided with special sense structures as sensilla and sensoria. The terminal segment is characterized by the presence of a primary sensorium at the apex of the segment, and the prolongation of the segment beyond the sensorium as a slender filament, known as the spur, which carries a group of sensilla on the distal end, very constant and characteristic of the family. The subterminal segment is also provided with one of the primary sensoria near its apex.

Various types of sensilla (sense hairs) are present on the antennae which have considerable taxonomic value and may be distinguished under the following heads: First, the long and slender hair-like sensilla of the flagellum as present in the Lachnina and related tribes. Second, the short and spine-like sensilla of the Aphidini. Third, the glandular sensilla with enlarged apices of the Macrosiphini. Fourth, the apical sensilla of the spur just referred to. The sensoria (sense membranes) are of many kinds and very characteristic of the family. The following types may be recognized: First, the reticulations or

transverse folds of the flagellum. Second, the primary sensoria, usually fringed with a row of hairs, one on the terminal segment close to the base of the spur; and a second on the subterminal segment near the apex. The primary sensoria are the first to appear and are usually present in the larvae in the earliest stage as well as in the adult; they are the most constant of all the sensoria. Third, the secondary sensoria, variable in number and position on the segments of the flagellum, are characteristic of the adult but may be present in the larva as well. The secondary sensoria are usually circular like the primary, but in the Pemphiginae and forms with shortened antennae they become crowded and may be transverse or annulated, extending around the segment like a ring. Fourth, the marginal sensoria, a group of five or six small sensoria close to the margin of the primary sensorium of the terminal segment. The arrangement of the marginal sensoria shows two distinct types: first, where they are scattered over some area, as in the Lachnina and related tribes, which may be considered as the primitive condition of the family; second, where they are grouped close together in a row or in pyramidal form as in the Aphidina. Sensoria may also be present on other parts of the body, on the coxa, the hind tibiae of oviparous females, on the wing-veins, and on the spur of the antennae (*Mordwilkoja*). The rostrum is typically composed of five segments, which is undoubtedly the primitive condition of the family from which the more common four-segmented condition has come by fusion of the two terminal segments. The five-jointed condition is clearly seen in the Lachnini. In some aphids the prothorax is provided with lateral protuberances or tubercles, the significance of which is obscure. Similar tubercles may also be found on the segments of the abdomen, which indicates an original segmental condition of these bodies. They are seen at their best in the Pterocommini and certain Aphidini.

The long and slender legs of the Lachnina and the Macrosiphini show undoubtedly the primitive condition of the family; the reduction of the legs reaches its furthest in the gall and underground forms of the Pemphiginae; atrophied and greatly modified tarsi are known only for some of the more specialized genera of the Aphidini. The simple venation of a Pemphigus is not to be considered as the primitive type, but rather the complete venation of the Aphidinae from which the secondary types are derived by reduction or loss of certain veins. Too great value has been given to venation by most writers in establishing the larger groups of the family. Modifications of the type form (Lachnina) by reduction or loss of certain veins are found to have taken place in several of the tribes, producing parallel and convergent

forms which are not necessarily closely related. The cornicles are the most characteristic structures of the family. Nothing homologous to them has been found in related families of the Homoptera, though such organs probably occur. Several distinct types of cornicles may be distinguished. First, the tuberculate type in which the short cornicles are situated on cone-shaped and hairy tubercles of the body, as present in the Lachnina. Second, the truncate type in which the cornicles are usually not longer than broad and not found on hairy tubercles; this type is characteristic of the Chaitophorina and the Callipterina. Third, the cylindrical type as present in the Aphidina. The Pemphiginae have the cornicles reduced to mere pores or are wanting. Attention has often been called to the correlation of greatly developed cornicles with the corresponding great development of the cauda. In the Lachnina the cauda is inconspicuous; the Chaitophorina and Callipterina have the cauda triangular and pointed at apex or sometimes enlarged (globose); the triangular and pointed cauda is also characteristic of the Aphidina, where the cauda reaches its greatest development in the Macrosiphini correlated with the great development of the cornicles of this group. The Pemphiginae have inconspicuous cauda correlated with the reduction or loss of the cornicles.

Biological characters. Aphids are among the most defenseless of insects, their soft bodies make them an easy and coveted prey to their many enemies. Their strength lies in their great power of reproduction, by which they more than hold their own against all their enemies. The parthenogenetic mode of reproduction has become characteristic of the family, probably more so than in any other group of insects. Generation will follow generation in rapid succession through the season. Aphids are among the first insects to become active in spring when they have the field all to themselves before their enemies make their appearance. During the height of the season, when their enemies have all but cleaned them out of their old haunts, the winged generations have appeared and they are carried by their wings and the wind far and wide to establish new colonies in innumerable places. When the cold of the fall has laid low their enemies, the aphids continue to spread and multiply, and among the last insects of the season are the sexes which then develop and deposit their winter eggs.

Protective resemblance is present to a marked degree in some species, by which they escape their enemies. In the Pemphiginae special protective structures are of common occurrence. The wax-like secretions, so common in this group, envelop the individual and the

colony in a protective covering; some find their protection in folded leaves, or in galls; many find their protection under ground on roots of plants.

The number of generations for the season varies greatly; while some produce only a few, in others the generations follow in rapid succession. The successive generations may show considerable differences in structure, so much so that they would easily be considered as different insects. The following five types of generations may be considered as typical of the family. First, the fundatrix (foundress or stem-mother), the individual that comes from the egg and gives rise to the following generation; the fundatrix is always apterous. Second, the spuriae (wingless viviparous females or spuriae apterae); the second may have a number of successive generations all alike. Third, the migrants (winged viviparous females or spuriae alatae vel migrantes), which acquire wings and serve for the distribution of the colony; this generation may be followed by one or more generations of spuriae that are counterparts of the second type. Fourth, the sexuparae, the last generation of spuriae (apterous or alate) with which the parthenogenetic mode of reproduction comes to an end for the season and which produces the following type. Fifth, the sexuales or true sex forms, the males and females, which, after copulation, produce the true ova which remain over winter for the next season. While the females are always apterous, the males may be either alate or apterous. The succession of generations in the order given may be considered as typical of the family, to which many exceptions are found in the different groups. Thus the second generation may be composed of migrants, followed by spuriae, or there may be several generations of migrants following each other or at various times during the season; a generation of spuriae may produce in part spuriae and in part migrants. Aphids appear to be greatly influenced by external changes and conditions; under favorable conditions they will continue to produce generation upon generation of spuriae, but with changed conditions of temperature and nature of the food only migrants are produced. The Callipterina constitute a remarkable exception in that all the parthenogenetic generations acquire wings before reproducing.

Aphids feed upon juices of plants. The part of the plant to which they have become adapted is various but may be considered under the following heads. First, the bark feeders (*corticola*), found on woody parts of trees and other woody plants. Second, the root feeders (*radicola*), feeding underground at base of the trunk or on roots. This type may be considered as an early adaptation of the first type and is common in the Pemphiginae. Third, the leaf feeders

(folicola) feeding on the tender twigs and leaves of trees and woody plants. Fourth, those feeding on annual plants (herbicola), which undoubtedly represent the latest type of development in the direction of food habitat.

KEY TO THE SUBFAMILIES OF THE APHIDIDAE

1. Typical Aphididae in which the aphidian characters are usually expressed by increase or additions, as seen in the development of the spur and sensoria of the antennae; and in the great development of the cornicles and cauda. The group is typically aerial in habitat. . . . **Subfamily APHIDINAE**

—Specialized Aphididae in which the typical aphidian characters are specialized in the line of reduction or loss, as seen in the number of segments to the antennae, in the spur, sensilla and sensoria; in the reduction or loss of the cornicles and cauda; reduction in venation is also carried further in this group than in the preceding. The group is typically subterraneous or protected in habitat, as found in folds of leaves, in crevices of bark, or in galls. Positive pemphigian characters are seen in the great development of dermal glands. . . . **Subfamily PEMPHIGINAE**

SUBFAMILY APHIDINAE

- Retzius, 1783, DeGeer's Genera. Sub "Fam. I. Abdomen corniculatum."
 Latreille, 1807, Gen. Crust. Vol. 3. Sub Bicorniculatum et bituberculatum.
 Leach, 1818, Trans. Hort. Soc. Vol. 2 Sub Eriosoma (genus).
 Burmeister, 1835, Handb. Entom. Vol. 2. Sub Lachnus (genus).
 Koch, 1854, Die Pflanzenl. Heft 1. Sub Dikyphonen et Monokyphonen.
 Passerini, 1863 Aphid. Ital. Sub Aphidinae et Lachninae (subfamilies).
 Buckton, 1876, Monogr. Vol. 1. Sub Aphidinae (subfamily).

The subfamily Aphidinae was foreshadowed by Retzius (1783) and Latreille (1807) in their grouping of the species of the genus *Aphis*. Leach (1818) first indicated the Pemphiginae by the genus *Eriosoma*, restricting the genus *Aphis* as representative of the present subfamily. Burmeister further divided the genus by erecting the genus *Lachnus* which became the foundation of Passerini's subfamily Lachninae. Koch (1854) indicated the subfamily names *Dikyphonen* and *Monokyphonen*, both of which are nomina nuda. Buckton (1876) united Lachninae with Aphidinae which is now generally taken as the natural limits of the subfamily.

Morphological characters. The positive characters of the subfamily are seen in the gradual increase or direct development of the antennae and the spur, the sensilla and sensoria, and the cornicles and cauda. The Pemphiginae, on the other hand, show a non-development or reduction and loss of the same characters.

Biological characters. Three distinct stages or steps of food habitat may be distinguished in the present subfamily. First, those feeding on woody part of trees, which is undoubtedly the primitive food-habitat of the family. This is characteristic of the Lachnina and the more generalized Chaitophorina. Second, those feeding on tender

twigs and leaves of trees and woody plants; characteristic of the Chaitophorina and Callipterina. Third, those feeding on annual plants as characteristic of most of the Aphidina. In form of the parthenogenetic generations two distinct types may be distinguished in the subfamily. First, where all the parthenogenetic generations acquire wings before reproducing, as in the Callipterina. Second, where these same generations are either winged or wingless which is the condition of the other groups of the subfamily.

KEY TO THE GROUPS OF TRIBES OF THE APHIDINAE

1. Cornicles short and rim-like situated on cone-shaped hairy tubercles; antennae usually less than one-half the length of the body and provided with long hairs; spur short. Found on the bark of woody plants. . . . **I. LACHNINA**

—Cornicles not situated on hairy tubercles, cylindrical and conspicuous, sometimes much reduced or variously modified, rarely hairy (Trichosiphini). Usually found on annual plants or the growing parts and leaves of woody plants. . . . **2.**

2. Cornicles short and of the truncate type; if longer than broad then variously enlarged, rarely cylindrical. . . . **3.**

—Cornicles long and cylindrical; sometimes short but then not of the truncate type. . . . **4.**

3. Antennae and legs with long slender hairs; cauda broad or pointed, rarely enlarged at apex; the parthenogenetic summer generations in part wingless (Spuriae) and in part winged (Migrants); colonies usually strongly gregarious; found on the leaves of woody plants, sometimes on bark. . . . **II. CHAITOPHORINA**

—Antennae and legs smooth or with short hairs; cauda usually globate at apex and anal plate more or less emarginate; the parthenogenetic summer generations all acquire wings (Migrants) before reproducing; colonies sporadic, i. e. more or less scattered; found on leaves of woody plants, rarely on annuals. . . .

III. CALLIPTERINA

4. The cylindrical cornicles provided with numerous long, spreading hairs; Asiatic forms. . . . **IV. TRICHOSIPHINA**

—Cornicles not hairy, or at most with a few hairs; found mostly on annual plants, sometimes on leaves of woody plants. . . . **V. APHIDINA**

I. GROUP LACHNINA

Retzius, 1783, DeGeer's Genera. Sub Abdomen tuberculatum.

Latreille, 1807, Gen. Crust. Vol. 3. Sub Abdomen bituberculatum.

Burmester, 1835, Handb. Entom. Vol. 2. Sub Lachnus (genus).

Koch, 1854, Die Pflanzen. Heft 1. Sub Lachniden (tribe).

Passerini, 1863, Aphid. Ital. Sub Lachninae (subfamily).

Buckton, 1876, Monogr. Vol. 1. Sub Aphidinae (subfamily).

Thomas, 1879, Report 8. Sub Lachnini (tribe).

Mordwilko, 1908, Acad. Imper. Vol. 13. Sub Lachnina (group).

The group Lachnina has been long in coming to its present limits and position in the family. The group was foreshadowed by Retzius (1783) and Latreille (1807). Burmeister (1835) erected the genus Lachnus, the foundation of the present group. Koch (1854) united a second genus with Lachnus under the tribal name Lachniden which is a nomen nudum. Passerini (1863) first gave the group the subfamily name Lachninae. Buckton placed it as a tribe under the Aphidinae.

Thomas (1879) named the tribe Lachnini. Mordwilko (1895-1908) first clearly indicated the limits of the group under the term Lachninae which he later changed to the better term Lachnina.

Morphological characters. Head transverse, with frontal margin broad and straight. Antennae have six segments, rarely only five; usually less than half the length of the body; spur of the terminal segment short and undeveloped; segments of the flagellum provided with numerous long, spreading hairs; secondary sensoria mostly large and circular, but variable in number and position; marginal sensoria more or less scattered and not forming a compact group. The rostrum is usually long, sometimes as long as or longer than the body. In the Lachnini the rostrum is distinctly 5-jointed. Legs long and slender, the hind pair especially so; they are usually provided with long and spreading hairs like those on the body. Wings are large and the venation is typical of the family; stigma long and slender, rarely short and broad; stigmal vein (Rs) originating from the distal end of the stigma and runs as a straight vein to the margin, or, when originating some distance from the apex of the stigma, it is more or less curved; the media is a very faint vein in the Lachnini, but more distinct in the Pterochlorini. The cornicles are short, often mere pores, situated on conspicuous cone-shaped, hairy tubercles which are seldom much reduced or wanting. The cauda is short and broad and not conspicuous.

Biological characters. It becomes apparent from extended morphological and biological studies on the family that the Lachnina represent the most generalized and primitive forms of the Aphididae that are in existence at the present time, and that they give the key to the phylogenetic understanding of the family. This is indicated by their size, form of the antennae, the structure of the sensilla and sensoria, the long rostrum with the free distal segment, the venation, and the form of the cornicles and cauda. But more so does the habitat of the group, as bark feeders on conifera and deciduous trees, indicate that they are a remnant of a group that in the past predominated and gave characters to the family. Paleontology also, as far as known, points to similar conclusions.

KEY TO THE TRIBES OF THE LACHNINA

1. Stigma long and stigmal vein takes its origin from the distal end of the truncate stigma and runs as a short, straight vein to the margin; media appears as an indistinct vein. They are found feeding on the bark of coniferous trees. . . .

1. Tribe LACHNINI

—Stigma long or sometimes short, with the stigmal vein arising some distance back from the apex of the stigma and curved more or less before reaching the margin; media slender but distinct. They are found feeding on the bark of deciduous trees and woody plants. . . .

2. Tribe PTEROCHLORINI

I. TRIBE LACHNINI

- Kaltenbach, 1843. Monogr. Sub **) Radialzelle etc.
 Koch, 1855. Die Pflanzenl. Heft 7. Sub Lachnus (genus s. str.)
 Mordwilko, 1895 Zool. Anzeig. Vol 18. Sub "Baumläuse".
 Cholodkovsky, 1898. Beitr. Monogr. Sub "Coniferen-läuse."

Hartig (1841), in his definition of the genus based on venation, undoubtedly had in mind a true Lachnus as the type but included also the heterogeneous forms of Burmeister to which he adds further. Kaltenbach (1843) recognized this polygeneric condition and remarks that the genus can not long continue as such; he separates the included forms in two sections, the second of which in main corresponds to the present tribe. Koch (1855) restricts the genus Lachnus to include the conifer forms. Mordwilko (1895) treats the genus Lachnus (Burm.) Koch in a tribal sense, in which he is followed by Cholodkovsky (1898).

Morphological characters. The distinguishing characters of the present tribe are found in the venation of the wings. The stigma is long and narrow, and the stigmal vein takes its origin near the distal end of the more or less truncated stigma and runs as a short and straight vein to the margin of the wing. The media appears as a faint and indistinct vein; it is normally two-branched but sometimes with only one branch or simple. The Lachnini are further distinguished by their five-jointed rostrum.

Biological characters. The Lachnini are mostly large; in color brown or black, those feeding on the needles alone show the green so common and characteristic of the family. They are all but confined to conifers, feeding on the trunk and limbs, or on the tender twigs and needles. They have a wide distribution in the temperate zone, but have the appearance of a vanishing group with the gradual restriction and disappearance of the Conifera.

2. TRIBE PTEROCHLORINI

- Rondani, 1818. Ann. Sci. Nat. Bologna, Vol. 9. Sub Pterochlorus (genus).
 Koch, 1855. Die Pflanzenl. Heft 7. Sub Dryobius (genus).

The Pterochlorini are here recognized for the first time as a distinct tribe; the forms included have hitherto been considered with the Lachnini. Rondani (1848) first established the genus Pterochlorus with *Aphis roboris* L. as type. Koch (1855), not aware of Rondani's paper, proposed the generic term *Dryobius* for the same species as type, to which he added a second also from the oak. The tribe is

readily separated from the preceding by structural as well as biological characters.

Morphological characters. Antennae six-jointed. Rostrum somewhat shorter and stouter than in Lachnini; apparently four-jointed; some forms of the tribe are provided with an exceptionally long rostrum, much longer than the body, which is evidently an adaptation and of secondary value. Wings usually long with distinct venation; the stigma elongated and coming to a point at the apex, rarely approaching the truncate; forms with short wings have a short and broad stigma; stigmal vein takes its origin some distance back of the apex of the stigma and runs as a straight vein to the margin of the wing except for a short curve close to its origin. Forms with short stigma have a strongly curved stigmal vein. The media is twice branched and appears as a stronger vein than in the Lachnini.

Biological characters. The Pterochlorini are among the largest of our aphids, with exceptionally long hind legs. The group is found as bark feeders on the trunk and limbs of deciduous trees and other woody plants; more rarely underground near the base of the trunk or on roots. They are usually found in more exposed places than the shade loving Lachnini; they are, therefore, more highly colored, the wings often with dusky bands along the veins and with dusky spots. In their essential characters they show a close relationship with the Lachnini.

II. GROUP CHAITOPHORINA

Koch, 1854-1857. Die Pflanzenl. Sub Aphiden, Phyllaphiden, et Vacuniden.

Passerini, 1863. Aphid. Ital. Sub Aphidinae, Lachninae et Chermisinae.

Buckton, 1876-83. Monogr. Sub Aphidinae et Pemphiginae.

Thomas, 1879. Report 8. Sub Aphidini Lachnini et Pemphiginae.

Oestlund, 1887. Bull. 4. Sub Callipterini.

DelGuercio, 1900. Nuov. Relaz. Vol. 2. Sub Aphidinae et Myzoxylinae.

Mordwilko, 1907-8. Acad. Imper. Vol. 13. Sub Aphidina, Callipterina et Pemphiginae.

Wilson, 1910. Canad. Entom. Vol. 42. Sub Callipterinae.

The genera of the present group have for a long time been distributed under the various groups or tribes of the Aphidina, Lachnina, Callipterina and Pemphiginae and only recently have they been united under a common name. Koch (1854) first established the genus Chaitophorus under his Aphiden, other related genera were placed by Koch in the Phyllaphiden and Vacuniden. Passerini (1863) placed most of the genera in the Aphidinae, except that Siphia was placed in the Lachninae, and Vacuna with the Chermisinae. Buckton (1876-1883) distributed the genera treated in part under Aphidinae and in

part under the Pemphiginae. Thomas (1879) has the genera distributed under Aphidini, Lachnini, and Pemphiginae. Oestlund (1887) united Chaitophorus and related genera with Callipterus and related genera under the tribal name Callipterini, based mainly on similar type of cornicles and cauda. Mordwilko distributes the genera under the subfamilies Aphidinae and Pemphiginae. Wilson (1910) first united the genera under the three tribes Pterocommini, Chaitophorini, and Vacunini in the Callipterinae. The three tribes of Wilson are considered under the group Chaitophorina.

Morphological characters. Head transverse; frontal margin straight or but slightly concave. Antennae usually shorter than the body and not on frontal tubercles, or on very indistinct ones; spur of terminal segment elongated and distinct, usually longer than the proximal part; sensilla long and slender as in the Lachnina, but not as numerous; marginal sensoria sometimes scattered but more often grouped close together near the margin of the primary sensorium. Rostrum very short in the leaf inhabiting forms, longer in the bark feeders. Wings with typical venation, or reduced in the Vacunini; veins often found in dusky bands. Cornicles of the truncate type; usually not longer than broad, or if longer more or less enlarged in the middle. Cauda short and broad as in Lachnina, or elongated and pointed; in some the apex is distinctly globate as in the Callipterina. Anal plate with distal margin entire, rarely slightly emarginated. Body usually elongate and somewhat depressed, provided with long hairs. Distinctive characters of the tribe that separate them from the Lachnina are the short rostrum, the grouping of the marginal sensoria, and the cornicles and cauda.

Biological characters. Not a few of the present group are found as bark feeders on the trunk and limbs of deciduous trees; these are usually of a large size, approaching in this respect the Lachnina. The larger number of the group are found on tender twigs and on the leaves of trees, rarely on annual plants. The Vacunini are anomalous forms, which most writers have placed with the Pemphiginae on account of their one branched media and reduced cornicles, but a more critical examination of the tribe shows that they are better associated with the Chaitophorina. Following Hartig, too great weight has been given to venation by authors, and many unnatural relations have been established as a result. Venation is a character of primary importance in the family, but when taken unsupported by other characters has no more value than those of the antennae, cornicles, cauda, etc.

KEY TO THE TRIBES OF THE CHAITOPHORINA

- | | |
|---|-------------------------------|
| 1. Cornicles usually longer than broad and enlarged in the middle; size large. Found feeding on woody parts of trees. . . . | 3. Tribe PTEROCOMMINI |
| —Cornicles short and truncate; size smaller. Found feeding on leaves of trees. . . . | 2. |
| 2. Antennae of six segments. . . . | 4. Tribe CHAITOPHORINI |
| —Antennae of five segments. . . . | 5. Tribe VACUNINI |

3. TRIBE PTEROCOMMINI

- Koch, 1857. Die Pflanzenl. Heft 8. Sub Cladobius (Phyllaphiden).
 Passerini, 1860. Gli Afidi. Sub Aphioides (pro Cladobius).
 Buckton, 1879. Monogr. Vol. 2. Sub Melanoxanthus et Pterocomma.
 Mordwilko, 1894. Univ. Warsch. Sub Symdobiuss.
 Pergande, 1900. Proc. Wash. Acad. Sci. Vol. 2. Sub Cladobius (Koch) Perg.
 Kirkaldy, 1905. Canad. Entom. Vol. 37. Sub Aristaphis (pro Cladobius).
 Schoutenden, 1906. Mem. Belg. Vol. 12. Sub Melanoxantherium (pro Melanoxanthus).
 Wilson, 1912. Canad. Entom. Vol. 42. Sub Pterocommini (tribe).

The Pterocommini have only lately been recognized as a distinct tribe. Koch (1857) erected the genus Cladobius, the first generic distinction of the tribe. Passerini (1860) changed this to Aphioides as Cladobius was preoccupied. Buckton (1879) proposed two new genera, Melanoxanthus and Pterocomma, the second of which is now known to be the same as Koch's Cladobius and replaces this as Passerini's Aphioides also proves to be preoccupied. Mordwilko (1894) erected the genus Symdobiuss which is closely related to the present tribe. Pergande (1900) considers the American forms under Koch's term Cladobius in a somewhat enlarged sense. Kirkaldy (1905) makes a third attempt to replace the preoccupied term Cladobius under the name Aristaphis. Schouteden (1906) proposed Melanoxantherium to replace Melanoxanthus which also proves to be preoccupied. Wilson (1910) first recognized the tribe Pterocommini.

Morphological characters. Rostrum moderately long, but shorter than in the Lachnina. Antennae variable in length, usually shorter than the body, rarely as long as the body; terminal segment short and with a short but distinct spur; marginal sensoria sometimes scattered but more often grouped close together. Wings large and venation typical, veins sometimes with dusky bands. Abdomen usually with distinct lateral tubercles, a character sharply marked in the present tribe and again in the Aphidini; the significance of these organs is not known. Cornicles longer than broad and widest in the middle; rarely cylindrical, reduced or wanting. Cauda short and broad.

Biological characters. In size the present tribe includes all the larger forms of the group; all are bark feeders on woody parts of trees and in exceptional cases on roots. Body with long hairs and of

dusky colors. The close relationship of the tribe to the Lachnina is plainly seen in their size, colors, and especially in their habitat as bark feeders.

4. TRIBE CHAITOPHORINI

- Koch, 1854. Die Pflanzenl. Heft 1. Sub Chaitophorus (genus).
 Oestlund, 1887. Bull. 4. Sub Callipterini (tribe).
 Mordwilko, 1908. Ann. Acad. Imp. Vol. 13. Sub Chaitophorini (tribe).
 Wilson, 1910. Canad. Entom. Vol. 42. Sub Chaitophorini (tribe).

Koch (1854) recognized the essential characters of the tribe under the generic term Chaitophorus, which was placed under his Aphiden. Oestlund (1887) united Chaitophorus and related genera with Callipterus under the tribal name Callipterini. Mordwilko (1908) recognized the tribe Chaitophorini but included the Pterocommini. Wilson (1910) first recognized the tribe with its present limits.

Morphological characters. Frontal margin straight or nearly so with no antennal tubercles; antennae shorter than the body, provided with long spreading hairs like those on the body and appendages; rostrum short and stout, rarely extending beyond the third pair of legs. Cornicles short and broad, usually broadest at base, truncate at apex or with a narrow margin. Cauda short, rounded or triangular and rarely with the apex globose.

Biological characters. The Chaitophorini are nearly all found on leaves or tender twigs of deciduous trees, rarely on annual plants. They do not show the robust form of the Pterocommini and Lachnina, but are smaller with moderately short legs. In color they are usually found with more or less green in harmony with their habitat on the leaves of trees. The tribe shows close affinity to the Lachnina in their hairy body and appendages; as well as in their habitat on trees.

5. TRIBE VACUNINI

- Heyden, 1837. Mus. Senk. Vol. 2 Sub Vacuna (genus).
 Koch, 1854. Die Pflanzenl. Heft 1. Sub Vacuniden (tribe).
 Passerini, 1863. Aphid. Ital. Sub Chermesinae (subfamily).
 Thomas, 1879. Report 8. Sub Vacunini (section).
 DelGuercio, 1900. Nuov. Relaz. Vol. 2. Sub Vacunides (tribe).
 Mordwilko, 1908. Acad. Imper. Vol. 13. Sub Vacunina (group).
 Wilson, 1910. Can. Entom. Vol. 42. Sub Vacunini (tribe).

Heyden (1837) first recognized the genus Vacuna that foreshadows the present tribe. Koch (1854) placed Vacuna in his tribe Vacuniden which is a nomen nudum. Passerini (1863) placed Vacuna with Chermes in the subfamily Chermesinae. Thomas (1879) con-

sidered it as a section under the subfamily Pemphiginae. DelGuercio (1900) characterized the tribe Vacunides under the subfamily Pemphiginae. Mordwilko (1908) considers it as the group Vacunina under Pemphiginae. Wilson places it as the tribe Vacunini in the subfamily Callipterinae. In the present paper it is considered as a tribe in the group Chaitophorina.

Morphological characters. Antennae short, not much longer than the head and thorax combined; five segmented but often a six segmented condition is found in one or both the antennae of certain individuals; spur of the terminal segment very short, Rostrum short and stout. Wings held flat in repose; media one-branched; hind wings with only one oblique vein. Cornicles very short, extending but slightly above the surface of the body. Cauda short and rounded, or when longer then enlarged at apex or globate.

Biological characters. Small size. Found on smaller twigs and sometimes on the leaves of woody plants as birch, alder and dogwood. The tribe is remarkable in the extent of reduction that has taken place in the antennae, cornicles and venation, in convergence with the subfamily Pemphiginae.

III. GROUP CALLIPTERINA

- Koch, 1854. Die Pflanzenl. Heft 1. Sub Drepanosiphiden et Callipteriden.
 Passerini, 1863. Aphid. Ital. Sub Aphidinae et Lachninae (subfamilies).
 Thomas, 1879. Report 8. Sub Siphonophorini et Aphidini (subfamilies).
 Oestlund, 1887. Bull. 4. Sub Callipterini (tribe).
 Mordwilko, 1908. Ann. Acad. Sci. Vol. 13. Sub Callipterina (group).
 Wilson, 1910. Can. Entom. Vol. 42. Sub Callipterini (tribe).

Koch (1854) recognized the two tribes Drepanosiphiden and Callipteriden, both of which are nomina nuda. Passerini (1863) distributes the genera under the subfamilies Aphidinae and Lachninae, and Thomas (1879) under the tribal names Siphonophorini and Aphidini. Oestlund (1887) united the present group with the Chaitophorina under the tribal name Callipterini. Mordwilko (1908) first recognized the group under the term Callipterina. Wilson (1910) considers the same under the tribal name Callipterini.

Morphological characters. Antennae variable in length, spur likewise; never hairy as in the preceding group; secondary sensoria usually confined to the basal half of the third segment, arranged in a row; marginal sensoria often scattered or found in a row close to the primary. Rostrum short or at most moderately long. Venation typical; the stigmal vein often reduced, at least the basal part. Cornicles short and truncate like those of the Chaitophorina, rarely short cylindrical or

enlarged near the base. Cauda usually distinctly globate, sometimes straight and rounded at apex. Anal plate usually distinctly emarginated, often bifurcate.

Biological characters. In size the Callipterina vary from rather large to very small. They are found feeding on the leaves of woody plants and trees, rarely on annuals. The group has much in common with the Chaitophorina both in structure and habitat, but is sharply distinguished in that, with few exceptions, all the parthenogenetic generations acquire wings before reproducing. They are further distinguished by not forming large colonies but live scattered and show greater activity than usual in the family. Not a few of the species have the ability to leap, reminding one strongly of the Psyllidae.

KEY TO THE TRIBES OF THE CALLIPTERINA

1. Size large and *Microsiphum*-like; cornicles short, sometimes enlarged at base; cauda long and unusually straight with the apex rounded.
2. Cornicles rarely longer than broad, truncate at tip, rarely wanting; spur of the terminal segment usually not much longer than the basal part, sometimes shorter.
- Size moderately large to small; cauda globate.
- Cornicles longer than broad and enlarged; antennae and spur exceedingly long.

6. Tribe CALAPHIDINI

2.

7. Tribe CALLIPTERINI

8. Tribe DREPANOSIPHINI

6. TRIBE CALAPHIDINI

Walsh, 1862. Proc. Entom. Soc. Vol. 1. Sub *Calaphis* (genus).

The tribe is here recognized for the first time. Walsh (1862) first foreshadowed it by the genus *Calaphis* which gives the name to the tribe. It is a curious fact that we may recognize a race of large forms and one of small forms running through the subfamily Aphidinae. Tribes of the large race-form are some of the *Pterochlorini*, the *Pterocommini*, *Calaphidini*, and *Macrosiphini*.

Morphological characters. Antennae usually much longer than the body and situated on distinct frontal tubercles; front concave as in *Macrosiphum*. Rostrum short. Cornicles short, cylindrical, and sometimes enlarged at base. Cauda straight with a rounded apex. Anal plate entire or slightly emarginated, never deeply bilobed.

Biological characters. These large and *Microsiphum*-like forms are found on the leaves and tender twigs of alder and birch. The tribe has characters that ally it with the *Lachnina* as well as the *Microsiphini*, while its more fundamental characters place it naturally in the *Callipterina*. Some of the species at least are further characterized by wax glands on the body, legs and antennae, which

secrete an abundant white wax substance in tufts or bands that give them a very peculiar appearance, and may serve as a protection against some of their enemies.

7. TRIBE CALLIPTERINI

- Koch, 1855. Die Pflanzenl. Heft 7. Sub Callipterus (genus).
 Mordwilko, 1908. Ann. Acad. Sci. Vol. 13. Sub Callipterini (tribe).
 Wilson, 1910. Can. Entom. Vol. 42. Sub Callipterini (tribe).

Koch (1855) erected the first genus of the tribe. Mordwilko (1908) included most of the genera under the tribal name Callipterini. Wilson (1910) uses the term Callipterini in the sense of our Callipterina including the three tribes here distinguished.

Morphological characters. Front not deeply emarginate nor with frontal tubercles; antennae usually as long as or longer than the body; spur shorter than, equal to, or much longer than the proximal part of the segment. Venation normal, but stigmal vein often indistinct, at least the basal portion. Cornicles short and truncate, sometimes much reduced or wanting. Anal plate usually deeply emarginate, sometimes bilobed. Larval forms with distinct glandular hairs on the body.

Biological characters. The Callipterini have long been favorites with students of the family. Most delicate in structure and extremely variable in color and organization they have also been a favorable hunting ground for the genus makers. They are found almost exclusively on leaves of deciduous trees.

8. TRIBE DREPANOSIPHINI

- Koch, 1854, Die Pflanzenl. Heft 1. Sub Drepanosiphiden (tribe).
 Oestlund, 1887, Bull. 4. Sub Callipterini (tribe).

Koch (1854) recognized the tribe under the name Drepanosiphiden which is a nomen nudum. Oestlund (1887) considers it under the tribe Callipterini.

Morphological characters. Front more or less concave as in the Macrosiphini but the antennal tubercles are not large. Antennae as a rule much longer than the body; the extreme length seems to have been reached in this tribe of the family; spur of the terminal segment exceedingly elongated in comparison with the basal part which is short and not elongated as is usual in the Callipterini. Cornicles vary from short to long, and usually variously enlarged, departing from the cylindrical form. Cauda short and conical or even globose. Anal plate more or less emarginate.

Biological characters. The type form of the tribe appears very much like a Macrosiphum, with which it has generally been associated by authors. The more fundamental characters prove it closely allied to the Callipterina. They are sporadic and all the generations acquire wings before reproducing, a condition known only for the Callipterina. They are found on the leaves of various deciduous trees.

IV. GROUP TRICHOSIPHINA

- Westwood, 1890. Entom. Soc. Lond. Sub Siphonophora (genus).
 Schouteden, 1905. Spol. Zeyl. Vol. 2. Sub Greenidea (genus).
 Pergande, 1906. Entom. News, Vol. 17. Sub Trichosiphum (genus).
 Okajima, 1908. Bull. Tokyo, Vol. 8. Sub Trichosiphum (genus).
 Wilson, 1910. Ann. Ent. Soc. Am. Vol. 3. Sub Trichosiphini (tribe).

Westwood (1890) described the first representative of the tribe which he placed in the genus Siphonophora. Schouteden (1905) proposed the genus for Westwood's species. Pergande (1906) adds a second genus, Trichosiphum. Okajima (1908) describes additional species and suggests that the group perhaps represents a new subfamily. Wilson (1910) places the group as a tribe under the Aphidina.

Morphological characters. Antennae variable in length and composed of five or six segments; spur variable but longer than the proximal part; antennae beset with long, spreading hairs as in Lachnina. Cornicles usually of the cylindrical type and very long and provided with long hairs like those on the body, antennae, and legs. Cauda short and triangular like the Aphidini.

Biological characters. This interesting tribe seems to be confined to Asiatic countries, India and Japan, and is imperfectly known. All the forms so far made known are feeders on leaves of woody plants. The venation and long cylindrical cornicles would seem to place them close to the Microsiphini, but their exceedingly hairy cornicles and body indicate a still closer relationship to Lachnina. As the tribe does not come within our area it may be passed with only an indication of its position in the family. One tribe is known, the TRICHOSIPHINI.

V. GROUP APHIDINA

- Linnaeus, 1758. Syst. Nat. Ed. X. Sub Aphis (genus).
 Burmeister, 1835. Handb. Entom. Vol. 2. Sub Aphidina (family).
 Koch, 1854. Die Pflanzenl. Heft 1. Sub Aphiden (tribe).
 Passerini, 1863. Aphid. Ital. Sub Aphidinae (subfamily).
 Thomas, 1878. Bull. Ill. State Lab. No. 2. Sub Aphidini (tribe).
 Mordwilko, 1908. Accl. Imper. Vol. 13. Sub Aphidina (group).

Linnaeus (1758) laid the foundation of the present group in the genus Aphis. Burmeister (1835) applied the term Aphidina to the

family. Koch (1854) indicated the genus *Aphis* with several other genera as the tribe Aphiden which is a nomen nudum. Passerini (1863) considers it under the subfamily name Aphidinae. Thomas (1878) has the term Aphidini in a tribal sense. Mordwilko (1908) first used the term Aphidina as a group including the tribes Chaitophorini and Aphidini.

Morphological characters. Frontal margin between the antennae straight or nearly so, or, more commonly, concave, the angles of the head being drawn out into frontal tubercles on which the antennae are situated. Antennae usually as long as or longer than the body; spur always elongated, sometimes exceedingly long. Sensilla of the antennae are sometimes hair-like, usually spine-like, capitate, or spatulate. Prothorax and abdomen often with lateral tubercles like those found in the Pterocommini. Cornicle cylindrical and long, sometimes enlarged or widened. Cauda conspicuous and triangular or pointed. Anal plate entire.

Biological characters. This is the largest group in the family, containing something like one half of the species. Their classification is correspondingly difficult and has lagged behind the other groups which contain a smaller number of forms. The Aphidina contain the modern, progressive forms that have taken a prominent place in the insect world and are still expanding. While some continue to return to woody plants for ovipositing, the majority have become completely adapted to live on herbaceous plants. They are all strongly gregarious, forming large colonies.

KEY TO THE TRIBES OF THE APHIDINA

1. Frontal margin nearly straight, or with broad and shallow concavities; sensilla of the antennae short, spine-like and sharp pointed; sometimes long and hair-like, but never enlarged at apex; third segment of the antennae rarely with sensoria in the spuria. . . . **10. Tribe APHIDINI**

—Frontal margin usually deeply concave; sensilla of the antennae capitate or variously enlarged apically. . . . 2.

2. Frontal margin narrowly concave, at least in the apterous and larval forms, due to a glandular swelling of the antennal tubercles; sensilla of the antennae usually capitate, like those on the front and body in the larval forms. . . .

11. Tribe MYZINI

—Frontal margin broadly and deeply concave in the larval as well as in the adult forms; sensilla long and spatulate; those of the front, body and in larval forms usually hair-like; third segment of the antennae usually with sensoria in the spuria. . . . **12. Tribe MACROSIPHINI**

10. TRIBE APHIDINI

Morphological characters. Frontal margin straight, or with shallow concavities, the antennae not situated on conspicuous frontal tubercles. Sensilla of the antennae rarely hair-like as in Chaitophorini,

usually short, spine-like and sharply pointed. Spuriae rarely with sensoria on the third segment of the antennae. Prothoracic and lateral tubercles usually present. Cornicles cylindrical, sometimes swollen in the middle, rarely short and wanting; reticulation open and not forming closed cells as in Macrosiphini. Cauda cone-shaped, triangular or pointed with a basal clear area.

Biological characters. Size medium to small, never very large as the Macrosiphini. While some are found on succulent twigs and leaves of woody plants from which they usually migrate to herbs for the summer generations, returning in fall to the primary host plant to oviposit, most of them develop altogether on herbaceous plants. The variety of plants inhabited is very great; the largest number is confined to a single or at most a few closely related plants. Some seem to feed indiscriminately on a very large number of different plants.

11. TRIBE MYZINI

Morphological characters. Front concavity narrowed, especially in the larval forms, due to the glandular swellings on the inner side of the usually short frontal tubercles, which are strongly reticulated and provided with capitate sensilla like those on the antennae. Antennae usually much longer than the body; sensilla sometimes very short but distinctly capitate. In the larval forms the hairs of the body are also capitate, at least those on the front of the head. Cornicles long and cylindrical, usually club-shaped or enlarged near the apex. Cauda much as in the Aphidini.

Biological characters. In habitat the present tribe agrees in general with the Aphidini and Macrosiphini, but the presence of capitate hairs on the body in the larval forms indicates a different line of development and origin from the other two. Similar conditions of sensilla are found in the Callipterina, with which the Myzini may be considered to converge, or it is possible that they have diverged from a common stock of the past.

12. TRIBE MACROSIPHINI

Morphological characters. Front deeply and broadly concave, antennal tubercles usually distinct. Antennae usually much longer than the body; sensilla usually long and spatulate or widened spear-like at apex. Sensilla on the head and body usually hair-like, the same as in larval forms. Cornicles cylindrical, sometimes widest in the middle; reticulation closed, forming cell-like arrangement on

the distal end of the cornicles. Cauda long, with an apical, narrowed prolongation turned upward. Spuriae usually provided with sensoria on the third segment of the antennae.

Biological characters. The present tribe is evidently a continuation of the large race of the Aphidinae, as met with in Calaphidini, Pterocommini, and Pterochlorini. In habitat they agree with the Aphidini, most of them are to be found on herbaceous plants.

SUBFAMILY PEMPHIGINAE

- Retzius, 1783, DeGeer's Genera. Sub Abdomen tuberculatum.
 Latreille, 1807, Gen. Crust. Vol. 3. Sub Abdomen corniculis tuberculisque nullis.
 Leach, 1818, Hort. Soc. Lond. Vol. 3. Sub Eriosoma (genus).
 Hartig, 1837, Jahresb. Vol. 1. Sub Pemphigus (genus).
 Koch, 1854, Die Pflanzenl. Heft 1. Sub Monokyphonen et Trichotomen.
 Passerini, 1863, Aphid. Ital. Sub Pemphiginae (subfamily).
 Kirkaldy, 1906, Can. Entom. Vol. 38. Sub Eriosomatinae (subfamily).

Retzius (1783) and Latreille (1807) foreshadowed the subfamily by their grouping of the genera of the genus *Aphis*. Leach (1818) established the first genus of the group, and Hartig (1837) the genus *Pemphigus* which has given name to the subfamily. Koch (1854) recognized the two subfamilies *Monokyphonen* and *Trichotomen*, both of which are *nomena nuda*. Passerini (1863) first proposed the subfamily *Pemphiginae*, in which he has been followed by most writers. Kirkaldy (1906) proposed *Eriosomatinae* to replace the term *Pemphiginae*.

Morphological characters. Frontal margin more or less convex; a transverse line touching the anterior margin of the eyes, as seen from below, cuts the antennal attachment (foramen); the antennal foramen has moved ventrad so that the antennae are situated between the eyes and not in front of them as seen in the Aphidinae. Antennae usually very short, of three to six segments; spur usually very short, rarely elongated (*Mordwilkoja*); sensilla few and inconspicuous or wanting, except in *Anoeciini*; sensoria usually transverse or annulate, sometimes circular. Rostrum short or at most moderately long, often wanting in the true sexes. Venation reduced, media rarely twice branched, usually with one branch or simple. Cornicles much reduced, rarely raised above the surface, often wanting. Cauda usually short and broad. Dermal glands in most cases characteristically arranged in larger areas along the margin of the abdomen and on the dorsum, more exceptionally also present as such on the thorax and head.

Biological characters. The *Pemphiginae* constitute a small group in comparison with the preceding. Species are not numerous but so

greatly differentiated that the number of genera is proportionally great. The positive characters of the Aphidinae, the development of the antennae, frontal tubercles, spur, venation, cornicles and cauda, all appear as negative in the Pemphiginae. Positive characters of the Pemphiginae are seen in the great development of the dermal glands arranged into areas, often very conspicuous on account of the secretion of waxy substance under which many of them find protection; gall structure is also a very positive character of the group. While the Aphidinae live more or less exposed, depending more on their extraordinary power of reproduction in order to hold their own, the Pemphiginae, on the other hand, seek protection by concealing themselves, under wax, in crevices of bark, in folds of leaves, in true galls, or underground on roots of plants. This instinct may be considered as the distinguishing character of the subfamily, which has expressed itself in all their structures.

KEY TO THE GROUPS OF THE PEMPHIGINAE

1. Fundatrix with six segments to the antennae; sexes with rostrum; found on bark of woody plants. **VI. Group PHYLLAPHIDINA**
—Fundatrix with fewer than six segments to the antennae; sexes usually without rostrum; usually found on leaves of trees and woody plants. 2.
2. Radial sector arising from the radius back of the stigma, or from the proximal end of the stigma; found on conifers. **VII. Group MINDARINA**
—Radial sector arising from the middle of the stigma; usually some of the generations are found in twisted or folded leaves or producing true galls on trees or woody plants. 3.
3. Fundatrix with five segments to the antennae; often found in pseudogalls, i. e., twisted or folded leaves of trees. **VIII. Group SCHIZONEURINA**
—Fundatrix with four segments to the antennae; usually found in true galls produced on tender twigs, buds, or leaves of trees. **IX. Group PEMPHIGINA**

VI. GROUP PHYLLAPHIDINA

- Koch, 1854, Die Pflanzenl. Heft 1. Sub Phyllaphiden (tribe).
 Passerini, 1863, Aphid. Ital. Sub Lachninae (subfamily).
 Mordwilko, 1908, Acad. Imped. Vol. 13. Sub Callipterini (tribe).

Koch (1854) first recognized the present group under the tribal name Phyllaphiden which is a nomen nudum. Passerini (1863) placed Koch's Phyllaphis in the subfamily Lachninae. Mordwilko (1908) considers it under the tribe Callipterini. Authors up to the present have considered Phyllaphis under the Aphidinae on account of the two-branched media, while in other respects it shows the characters of the true Pemphiginae and should be considered as such.

Morphological characters. Front convex. Antennae short, have six segments and a very short spur; articulated to the head in shallow depressions or pockets; sensilla short and few (Phyllaphis), or long

and numerous like a *Lachnus* (*Anoecia*); marginal sensoria scattered or in a row close to the primary. Rostrum short or at most moderately long. Fore wings with a twice-branched media, or but one-branched in the *Anoeciini*. Cornicles pore-like. Wax glands small and scattered, or grouped in large lateral areas. Fundatrix with six segments to the antennae (four in some).

Biological characters. The *Phyllaphidina* live more or less exposed on twigs or on leaves of woody plants; one species is known to form a pod-like gall by the folding of the leaf. The present group may be said to contain the anomalous forms of the *Pemphiginae* that show more of the *Lachnina* and *Chaitophorina* characters than is the case with the more typical *Pemphiginae*. The two tribes included are not very closely related, and the arrangement may be looked upon as a provisional one until the life histories of the included forms become better known.

KEY TO THE TRIBES OF THE PHYLLAPHIDINA

1. Media twice branched as in *Aphidinae*; provided with gland areas secreting flocculent fibers. 13. Tribe **PHYLLAPHIDINI**
 —Media with one branch only; antennae with long hairs as in *Lachnina* and *Chaitophorina*. 14. Tribe **ANOECIINI**

13. TRIBE PHYLLAPHIDINI

Koch, 1857, *Die Pflanzenl.* Heft 8. Sub *Phyllaphis* (genus).

Koch (1857) first recognized the genus *Phyllaphis*, the only representative of the tribe at present.

Morphological characters. Front strongly convex. Antennae short; secondary sensoria oval or transverse, the marginal close to the primary in a row; spur of the terminal segment very short. Rostrum short. Fore wings with a two-branched media as in the *Aphidinae*. Cornicles pore-like. Anal plate very large and rounded and with a pair of lateral papilla. The glandular areas scattered over the dorsum or collected in two lateral areas on the posterior end of the abdomen.

Biological characters. Members of the present tribe are found on tender twigs and leaves of trees and woody plants, covered with an abundant flocculent matter. Very diverse forms have been described under the genus *Phyllaphis*, which further study may dispose of otherwise.

14. TRIBE ANOECIINI

- Koch, 1854, *Die Pflanzenl.* Heft 1. Sub *Schizoneuriden* (tribe).
 Mordwilko, 1908, *Acad. Imper.* Vol. 13. Sub *Schizoneurina* (group).
 Tullgren, 1909, *Ark. Zool.* Vol. 5. Sub *Anoeciina* (tribe).

Koch (1854) placed the genus *Anoecia* in the tribe Schizoneuriden which is a nomen nudum. Mordwilko (1908) has it under the group name Schizoneurina. Tullgren (1909) placed it as a distinct tribe under the term *Anoeciina*. We would consider it as an anomalous Pemphiginae which, provisionally, may be placed as a tribe in the group Phyllaphidina.

Morphological characters. Head convex in front; antennae of six segments and inserted in shallow depressions, moderately long and provided with long hairs reminding one strongly of the Lachnina; spur of the terminal segment short; secondary sensoria circular, the marginal scattered and of unequal size; reticulation indistinct or wanting. Rostrum moderately long. Media one-branched as in Schizoneura. Cornicles pore-like with rimlike margin slightly raised above the surface. Cauda short and rounded as in Lachmus. Dermal glands small and scattered, not forming areas. Sexes provided with rostrum.

Biological characters. The life history is imperfectly known. They are found inhabiting twigs and leaves of woody plants. It may be considered an open question if the present tribe would not find a more natural association with the Chaitophorina, than with the Pemphiginae. At least they have little in common with the Schizoneurini.

VII. GROUP MINDARINA

Koch, 1854, Die Pflanzenl. Heft 1. Sub Schizoneuriden (tribe).

Tullgren, 1909, Ark. Zool. Vol. 5. Sub Mindarina (tribe).

Koch (1854) placed the genus *Mindarus* with the Schizoneuriden. Tullgren (1909) considers it as a distinct tribe under the name Mindarina. We would consider this term as a group coordinate with the other groups of the subfamily, which at present contain but one tribe, the Mindarini.

Morphological characters. Front rounded and with a slight emargination just above the median ocellus. Antennae moderately long; spur very short; secondary sensoria slightly oval, the marginal scattered but close to the primary. Rostrum rather long, reaching the abdomen. Wings large; stigma elongated, extending almost to the median vein; stigmal vein almost straight and very long, originating from the radius back of the stigma or from the proximal end of the stigma; media one-branched as in Schizoneura. Cornicles or pores very small. Cauda short and pointed, extending beyond the anal plate. Gland areas when present margined and composed of equal facets.

Biological characters. The habitat of the group is very exceptional for the Pemphiginae, being found on conifers. The structural characters indicate a very distinct line and origin from the other groups of the subfamily.

15. TRIBE MINDARINI

Characters of the tribe are included with those of the group.

VIII. GROUP SCHIZONEURINA

Koch, 1854, Die Pflanzenl. Heft 1. Sub Schizoneuriden (tribe).

Buckton, 1876, Monogr. Vol. 1. Sub Schizoneurinae (tribe).

Thomas, 1879, Report 8. Sub Schizoneurini (section).

Mordwilko, 1908, Acad. Imper. Vol. 13. Sub Schizoneurina (group).

Koch (1854) first recognized the group under the tribal name Schizoneuriden with which he included much that is now treated otherwise; his term is a nomen nudum. Buckton (1876) makes use of the subfamily term in a tribal sense. Thomas (1879) treats it as a section under the subfamily. Mordwilko (1908) first makes use of the term Schizoneura in a group sense, but included the genera Anoecia and Mindarus.

Morphological characters. Head not so strongly convex as usual in the subfamily. Antennae moderately long, composed of six segments; sensoria strongly transverse and annulate, with the annuli forming complete rings. Fore wings with media usually one-branched, sometimes simple; stigma short and pointed distally and stigmal vein arising from the middle of the same. Cornicles appear as pores or are wanting. Cauda short and broad as in Lachnus. The gland areas are usually composed of large facets arranged more or less regularly. Fundatrices have five segments to the antennae.

Biological characters. The Schizoneurina are characterized by forming, for some of the generations, pseudogalls by twisting and folding the leaves, few forming a pouch-like gall. They are all, more or less, provided with flocculent matter for protection. In size they are among the largest of the subfamily. Migrations from one food plant to one different is very common, and not a few attack cultivated plants, especially roots, and thus are among some of our most destructive aphids. The favorite habitat of the group for hibernation and for the spring generations are Ulmus and Fraxinus.

KEY TO THE TRIBES OF THE SCHIZONEURINA

1. The large gland areas confined to the abdomen, or to the thorax and abdomen, but not found on the head. **16. Tribe SCHIZONEURINI**
- Large gland areas present on the head, thorax and abdomen. **17. Tribe PROCIPHILINI**

16. TRIBE SCHIZONEURINI

Koch, 1854, Die Pflanzenl. Heft 1. Sub Schizoneuriden (tribe).

Thomas, 1879, Report 8. Sub Schizoneurini (section).

Mordwilko, 1908, Acad. Imper. Vol. 13. Sub Schizoneurina (group).

The tribe is essentially the same as the group as treated by various authors. The recognition of the tribe followed from an attempt to clear up the close relationship found between the Schizoneurina and Pemphigina, associating the Prociphilini as a tribe with the Schizoneurina.

Morphological characters. The distinguishing characters of the tribe are the absence of gland areas on the head, and the arrangement of the large facets of the areas in a ring around a central area; the annuli of the antennae usually form complete rings; media usually one-branched.

Biological characters. The favorite food habitat for hibernation and early spring generations seems to be *Ulmus*.

17. TRIBE PROCIPHILINI

Koch, 1854, Die Pflanzenl. Heft 1. Sub Prociphiliden (tribe).

Koch (1854) considers that *Prociphilus* represents a distinct tribe which is placed between the Schizoneurini and Pemphigini. There are some reasons for this. The type genus at present is considered by most writers under the Pemphigini. In general appearance and habitat it is a Schizoneurina, in venation it shows close affinities to the Pemphigina.

Morphological characters. The distinguishing characters are the presence of obvious gland areas on the head and thorax as well as on the abdomen, which appears as a distinct line of development from those of Schizoneurini and Pemphigina. Media is simple and the venation of the hind wings is triradiate as in the Pemphigini.

Biological characters. The principal food habitat for hibernation and the spring generations is *Fraxinus*.

IX. GROUP PEMPHIGINA

Hartig, 1837, Jahresb. Vol. 1. Sub Pemphigus (genus).

Koch, 1854, Die Pflanzenl. Heft 1. Sub Pemphigiden (tribe).

Thomas, 1879, Report 8. Sub Pemphigini (section).

Buckton, 1881, Monogr. Vol. 3. Sub Pemphiginae (tribe).

Mordwilko, 1908, Acad. Imper. Vol. 13. Sub Pemphigina (group).

Hartig (1837) proposed the first genus that has given the name to the group as well as the subfamily. Koch (1854) first named the tribe Pemphigiden which is a nomen nudum. Thomas (1879) gave

it as a section. Mordwilko (1908) first suggested the term Pemphigina as a group.

Morphological characters. Antennae usually short; sensoria oval or ring-like as in the preceding group, but the annuli are usually incomplete not extending around the segment; in Hormaphidini the annuli are complete. Media usually simple and not branched; veins of the hind wings usually arranged in a triradiate fashion. Gland areas less conspicuous, the facets usually arranged irregularly and are smaller and more crowded. Cornicles wanting. Fundatrices with only four segments to the antennae.

Biological characters. The Pemphigina include all the true gall forms, migrating to various habitats for the summer but returning to their favorite plants in the fall for hibernation and the gall generations.

KEY TO THE TRIBES OF THE PEMPHIGINAE

1. Antennae of the migrants and spuriae with six segments; cauda and anal plate not obvious. **18. Tribe PEMPHIGINI**
 —Antennae of migrants and spuriae with three to five segments; cauda and anal plate obvious. **19. Tribe HORMAPHIDINI**

18. TRIBE PEMPHIGINI

Morphological characters. Antennae in migrants and spuriae composed of six segments; usually very short; sensoria transversely oval or as incomplete annuli, the ends of which do not meet or fuse. Media usually simple; cubitus and anal approximate at origin; veins of hind wings usually arranged in a triradiate fashion. Cornicles wanting, and cauda inconspicuous.

Biological characters. This tribe includes practically all the gall forms, that produce typical aphidian galls. The favorite food habitat for hibernation and for the gall generations appears to be *Populus*.

19. TRIBE HORMAPHIDINI

- Osten Sacken, 1861, Stett. Ent. Zeit. Vol. 22. Sub Hormaphis (genus).
 Börner, 1908, Monogr. Cherm. Sub Hormaphidinae (subfamily).
 Mordwilko, 1908, Acad. Imper. Vol. 13. Sub Hormaphidina (group).
 Tullgren, 1909, Ark. Zool. Vol. 5. Sub Hormaphidina (tribe).

Osten Sacken (1861) recognized the first genus of the present tribe. Börner (1908) considers the group to be of subfamily value and names it Hormaphidinae. Mordwilko takes it as a group under the subfamily Pemphiginae. Tullgren (1909) considers it as a tribe.

Morphological characters. Antennae of migrants and spuriae with three to five segments; sensoria annulate and forming complete

rings. Cornicles wanting. Cauda distinct, enlarged or globate. Anal plate divided or bilobed as in the Callipterina. Media simple; cubitus appearing as a branch of the anal; hind wings with one oblique vein.

Biological characters. The Hormaphidini represent the extreme of the Pemphiginae line of development. Their approach to the Coccidae may be looked upon as a convergence rather than any close phylogenetic relationship. Their favorite habitat for hibernation and gall generations are Hamamelis and Betula.

THE CONFUSED FLOUR BEETLE¹ (*Tribolium confusum* Duval)

BY R. N. CHAPMAN

Introduction

Perhaps the most widely distributed insect attacking flour and other cereals in Minnesota is the confused flour beetle, *Tribolium confusum* Duval. During the recent war emergency, when substitutes for wheat flour were being used and every effort was being made to conserve food, this insect came to the attention of many dealers, bakers, and householders. This beetle does not claim the attention of the millers as much as the Mediterranean flour moth, which spins silk and clogs the machinery, but it is nevertheless a pest which causes them much loss.

While conducting work on the insects affecting wheat flour and the so-called wheat flour substitutes, a considerable amount of work has been done on *Tribolium confusum* and this paper contains some of the results. This is to be looked upon as a preliminary report on work which is still in progress. The fact that the work is still in progress implies that there is no feeling of finality about the results, but it is thought that the material contained in this paper is suggestive of the final outcome of the work, and it may be of value to those concerned with *Tribolium confusum*.

DESCRIPTION OF THE VARIOUS STAGES

The descriptions of *Tribolium confusum* in the various stages of its life history have been published so many times that it is necessary to do little more than call attention to the accompanying plate which figures all of the stages (Pl. IV). The figures showing the actual size of the eggs as compared with the apparent size, when they are covered with flour, deserve attention. When first deposited, these eggs are covered with a viscid fluid which causes particles of flour or cereal to adhere to them, when it hardens, and in many cases it causes the eggs to adhere to the sides or bottoms of sacks or other containers. The apparent size of the eggs as they are found in nature depends, therefore, upon the coarseness of the cereal in which they are laid. A naked egg such as is figured (Pl. IV Fig. 1) measures 0.6 mm. x 0.3 mm., while an egg coated with ordinary wheat flour (Fig. 2) measures 0.8 mm. x 0.6 mm. and represents about the minimum size for a coated egg. In

¹ Published with the approval of the Director as Paper No. 154 of the Journal Series of the Minnesota Agricultural Experiment Station.

all of the coarser cereals the apparent size is much greater, as in bran or rolled products where it is difficult to separate the eggs from the flakes of cereal to which they adhere.

The entire larva of the sixth instar is shown in Pl. IV, Fig. 4 and the heads of larvae of the other five instars are represented in the proper proportion (Pl. IV Fig. 3 a,b,c,d,e). At first the larval head measures only 0.1456 mm. at its widest point, and the entire larva is only 0.91 mm. in length. At each moult the width of the head increases to such an extent that one can usually determine the instar of a given larva by measuring the head. As the result of the measurement of a large number of larvae it was found that the average head measurements for each of the six instars were 0.1456 mm., 0.182 mm., 0.273 mm., 0.364 mm., 0.546 mm. and 0.728 mm. Occasionally larvae were found which were almost intermediate between the usual measurements for two successive instars. In such cases it is not possible to determine with accuracy to which instar the larva belongs, except by following the individual life cycle until the time of pupation. However, the records of such individuals have shown them to be undersized larvae which continue to lag behind the usual size for each succeeding instar until they eventually emerge as undersized adults. Therefore it is usually safe to assume that a larva which has a head measurement intermediate between those given for two different instars belongs to the instar of the next larger head measurement.

The pupae (Pl. IV Fig. 6) have been found to average about 3.858 mm. in length and the average width of the heads, at the widest point, has been found to be about 0.819 mm. This size is, however, subject to the same variation as that of the larvae, as has been stated above. The sexes of the pupae have been distinguished by the external genital organs which may be seen on the terminal abdominal segment. The female possesses a pair of appendages on the terminal segment, while the male presents only indistinct elevations in this region. (Compare male and female Pl. IV Fig. 6.)

The variations in the size of the larvae and the pupae result in corresponding variations in the size of the adults. The measurements at hand vary from 3.55 mm. to 4.25 mm. The beetle figured (Pl. IV) is of average size and drawn in proportion to the larvae and the pupa.

THE LIFE HISTORY OF *Tribolium confusum*

The exact number of eggs laid by a female beetle has not been determined with any great accuracy. Ten pairs of adults were isolated upon their emergence and each pair was placed in a separate container.

They were placed in flour and kept at a temperature of 26°C. and in an atmosphere of about 70 per cent of relative humidity. The number of larvae found after various periods of time were recorded and used as an index of fecundity. The eggs are so difficult to distinguish when coated with flour that it has been found that a count of the larvae is more accurate than one of the eggs. There may be an error due to eggs which do not hatch and larvae which may die while very small and are overlooked in the count. After 42 days the ten pairs of adults had produced the following numbers of larvae: 1st, 41; 2nd, 23; 3rd, 20; 4th, 32; 5th, 50; 6th, 45; 7th, 12; 8th, 7; 9th, 7; 10th, male died, no larvae.

Some of the eggs are deposited on the sides or bottom of the container but the majority are deposited in the flour or cereal itself. In a small quantity of flour which had been exposed to beetles, 263 eggs were found, 8 of which were adhering to the sides of the container, 15 to the bottom, and the remainder were found by sifting the flour. In this case the error from overlooking eggs in the sifted flour would be much greater than that from overlooking eggs on the sides or bottom of the container, which was of glass.

Upon hatching, the young larvae moult, for the first time, in about 24 hours. The posterior end of the larva adheres to the eggshell for some time after hatching and the shell may be dragged about by the larva, if it is at the surface of the flour. In this case the larva may free itself only when it moults, leaving the skin attached to the eggshell. During the first instar the larva is whitish, but a short time after the first moult it assumes a yellowish color. Perhaps the lack of color in the first instar is due to the short duration of this instar which does not permit the formation of a sufficient amount of chitin to give color to the larva.

For a short time before each moulting, the larva is inactive and the body is large in proportion to the head. The skin splits dorsally over the head and the thorax, and the larva emerges. It is at first white, like the larva of the first instar, but after twenty-four hours it takes on a yellowish color. Immediately after moulting, when the larva has expanded as a result of being freed from the old skin, it has often been observed to remain quiet for a time. When examined in favorable light during this time of quiet, one may see small bubbles of air passing in through the oesophagus and back into the proventriculus. The apparent passiveness of the larva makes it appear as if the air were drawn in by suction as the body expands. The bubbles of air are retained and may be observed in larvae of almost any age.

The feeding activities of the larvae vary with the character of the material in which they may be found. In coarse, rolled, or ground cereals, the larvae wrap themselves about the pieces of food and hold onto them with their legs while they feed. When in finely ground material they crawl about, feeding as they go. When the material is very fine and the particles inclined to adhere together and form small masses, it often causes the larvae much trouble by catching on the hairs which project from their bodies and impeding their progress.

As the time for pupation approaches, the larvae become inactive very much as they do just before an ordinary moult, except that the period of inactivity is of longer duration and they become more greatly contracted. The pupa lies ventral side up, often with the old larval skin attached to the posterior end. It is at first white, later it becomes yellowish and at the end of its period it is quite dark brown.

FOOD HABITS

Tribolium confusum is known to feed upon a wide range of foods and is said to exhibit certain preferences. Dean¹ states that while it is primarily a flour pest, it also infests corn meal, cracked wheat, any dry starchy material, stored peanuts, beans, and even baking powder, ginger, and cayenne pepper. He states that it may show a preference for the sweet and more oily low-grade flours, but intimates that this preference is not a very marked one for the beetles are to be found in great numbers in the best patent flours. The general statement has often been made that insects prefer coarse cereals of a low grade.

In order to determine whether certain preferences actually exist, two lines of investigation have been pursued. Stocks of flour and ground cereals have been examined in storehouses to determine the percentage of infestation in the various products. In the laboratory, experimental methods have been employed to study the relative susceptibility of the various flours and cereals under controlled conditions.

THE RELATIVE INFESTATION OF WHEAT FLOUR AND WHEAT FLOUR SUBSTITUTES

In the examination of the cereals in the storehouses a uniform method of sampling has been adopted. A brass tube 2 cm. in diameter and 40 cm. in length was sharpened at one end and graduated on the

¹ Bull. 180, Kansas State Agr. Exp. Sta. 1913.

RECORDS OF FLOUR AND CEREAL INSPECTION

Kind of flour.	Establishment No.	Date of inspection	Date received	From Mill No.	Where stored	Room temp. degrees F°	Flour temp. degrees C°	Beetles per kilogram of flour
Spring wheat	1	11/ 8/18	10/ 1/18	1	Basement	18.0	17.5	2
Spring wheat	3	11/12/18	10/28/18	5	Work room	§	22.0	0
Spring wheat	6	11/16/18	11/15/18	1	Second floor storeroom	22.0	28.0	0
Spring wheat	6	11/16/18	10/28/18	7	Second floor storeroom	22.0	23.0	0
Spring wheat	6	11/16/18	10/25/18	8	Second floor storeroom	22.5	22.0	0
Spring wheat	6	11/16/18	10/23/18	1	Second floor storeroom	22.5	22.5	0
Winter wheat	1	11/ 8/18	10/19/18	1	Work room	18.0	18.0	0
Winter wheat	4	11/13/18	11/12/18	1	Second floor storeroom	22.0	15.0	0
Spring wheat	2	11/ 9/18	11/ 8/18	3	Second floor storeroom	21.5	21.5	2
Spring wheat	2	11/ 9/18	11/ 5/18	1	Second floor storeroom	21.5	21.5	0
Spring wheat	2	11/ 9/18	11/ 8/18	4	Second floor storeroom	21.5	18.0	0
Spring wheat	3	11/12/18	11/ 6/18	3	Work room	§	22.0	0
Spring wheat	4	11/13/18	11/12/18	1	Second floor	22.0	15.0	0
Spring wheat	5	11/13/18	11/ 5/18	1	Second floor	18.0	17.0	0
Spring wheat	2	11/ 9/18	9/ 6/18	1	Second floor	21.5	21.5	6
Whole wheat	8	11/22/18	9/ 6/18	3	Basement	18.0	18.0	350
Whole wheat	8	11/22/18	9/ 6/18	3	Basement	18.0	18.0	20
Whole wheat	9	11/25/18	9/ 6/18	?	Basement	§	25.0	0
Rye	1	11/ 8/18	3/15/18	1	Basement	17.5	17.5	40
Rye	2	11/ 9/18	11/ 5/18	2	Second floor	21.5	22.0	0
Rye	4	11/13/18	11/12/18	1	Second floor	22.0	17.0	0
Rye	6	11/16/18	11/ 2/18	1	Second floor	22.0	22.0	0
Rye	9	11/25/18	?	1	Basement	28.0	28.0	0
Corn	1	11/ 8/18	10/ 1/18	1	Basement	17.5	17.5	0
Corn	2	11/ 9/18	11/ 1/18	1	Second floor	21.5	22.0	0
Corn	3	11/12/18	10/28/18	5	Work room	§	18.0	3+
Corn	3	11/12/18	10/28/18	5	Work room	§	20.5	0
Corn	4	11/13/18	11/12/18	1	First floor	22.0	17.0	0
Corn	5	11/13/18	11/ 4/18	1	First floor	18.0	17.0	0
Corn	6	11/16/18	10/ 5/18	9	Second floor	22.0	22.0	0
Corn	9	11/25/18	?	9	Basement	23.0	25.0	0
Corn starch	1	11/18/18	9/20/18	1	Work room	18.0	18.0	0
Barley	3	11/12/18	11/ 4/18	1	Work room	§	21.5	0
Barley	5	11/13/18	11/ 4/18	1	First floor	18.0	16.0	0
Barley	6	11/16/18	11/ 2/18	1	Second floor	22.0	22.0	0
Barley	6	11/16/18	10/ 5/18	1	Second floor	22.0	22.0	0
Barley	9	11/25/18	?	1	Basement	24.0	26.0	3+
Wheat bran	5	11/13/18	10/23/18	6	First floor	18.0	17.0	0
Oat flour	6	11/16/18	6/ 5/18	?	Second floor	22.0	23.0	533

§ Varying.

outside to read in cc. This tube was thrust in between the stitches at the end of the flour sack and could be withdrawn full of flour without otherwise disturbing the sack. The sample of flour was then weighed and sifted. It was found that when the tube was slowly turned in one direction as it was being pushed in, the sample withdrawn would be of quite uniform weight.

Four samples were usually taken from the flour next to the outside of the sack. The sample was sifted with an Excelsior testing set.² The size of the standard bolting cloth varied with the character of the material under examination, but No. 5 was used whenever possible. After counting and removing the insects, the residue on the bolting cloth was taken to the laboratory and incubated to determine whether it contained eggs.

The history of the flour, in so far as it could be obtained, was tabulated on the record sheet for use in determining where the products became infested. All of the establishments recorded on the accompanying table were visited without any advance knowledge of the presence of insects. This investigation was undertaken so late in the season that insufficient material was examined to give significance to the results. However, the results are given here, for they are suggestive of a line of work which will add to our knowledge of relative infestation. (See Records.)

THE RELATIVE SUSCEPTIBILITY OF WHEAT FLOUR AND WHEAT FLOUR SUBSTITUTES

The experimental work on the relative susceptibility of the various flours and cereals to *Tribolium confusum* has proceeded upon the assumption that other things being equal, susceptibility may influence the number of insects which enter a flour in the first place; or the rate of development of the insects after entrance may lead to their accumulation in great numbers. In the first case it might be possible to account for the great number of insects in a certain flour by the fact that a great number chose to enter it in the first place. In the second case, assuming that equal numbers of insects entered each of a number of foods, the shortening of the life cycle in one of these would, in time, give it the appearance of being more susceptible than any of the other foods.

²The Excelsior testing set, manufactured by Hammond-Humberg Co., Minneapolis, Minn., consists of a sifting frame together with the silk bolting cloths No. 0000 standard to No. 16 standard inclusive.

In consideration of the first proposition, various flours were placed in cylindrical jars with removable partitions, which divided the jars into five equal sectors. Equal amounts of the five cereals to be used in the experiment were placed in the various sectors of the jar and the partitions were removed. The surface was then made as smooth as possible without packing the cereal and a small depression was formed in the center. The jars used were 10.5 cm. in diameter and the cereal was about three cm. in depth, except in Series 3 as recorded below. The beetles were placed in the depression in the center of the jar and, being thus surrounded by equal parts of the five different cereals, they were free to express their choice.

The experiments were carried out in the dark in order to eliminate light as a factor. The duration of the experiments varied from a few hours to several days, the length of time making little difference after the first few hours when the insects were exploring about. When the time between examinations extended into weeks another factor entered in, as will be shown later. Observations were made by replacing the partitions and removing the different foods to count the number of insects contained in them. When one hundred insects were used, the number found in any one flour would be the percentage of relative susceptibility of that flour as compared with the other flours used in the experiment. In making the counts, beetles which remained in the center and expressed no choice were disregarded. Consequently the figures given for the counts do not always total one hundred. In all cases where the average percentage is given the actual percentage of the beetles which did express a choice has been computed.

The relative susceptibility of five grades of wheat flour was studied in this way. Each series of experiments was performed with a different lot of beetles. The following results are the averages for each of the five series.

EXPERIMENTS WITH ADULT *Tribolium Confusum*

Flour	Series 1 Average of 8 counts per cent	Series 2 Average of 5 counts per cent	Series 3 Average of 6 counts per cent	Series 4 Average of 3 counts per cent	Series 5 Average of 3 counts per cent
First middlings	12.092	17.504	7.32	11.734	11.733
First sizings	12.092	10.914	6.52	14.064	14.063
First low grade	17.812	9.804	1.92	13.734	15.20
First tailings	20.672	14.204	1.92	17.064	16.330
Bran	37.332	47.514	82.320	43.404	43.730

These flours vary in refinement from the fine middlings to the bran. In Series 3 the materials were only 1 cm. in depth, which may account for the difference of percentages.

It will be noticed that the bran contained, on an average, about twice as many beetles as would be expected if they were equally distributed among the five flours which were used in the experiments. All of the other grades of flour show such slight variations from the expectation that the data proved nothing with regard to selection on the part of the beetles.

The invasion experiments with the larvae showed no selection. The percentages are all so near the expected twenty per cent that the differences are to be explained as chance variations.

Flour	Series 1 Average of 5 counts per cent	Series 2 Average of 7 counts per cent
First middlings	17.931	18.588
First sizings	17.373	17.247
First low grade	24.350	27.233
First tailings	22.435	20.272
Bran	17.921	16.481

The study of the susceptibility of the wheat flour substitutes did not yield any conclusive evidence of preference on the part of the beetles. The results at hand show such an amount of variation that conclusions must await the results of a more extended series of experiments. In this paper two series of experiments will be introduced for comparison with those in which the wheat products were used. Only four wheat flour substitutes were used and the first low grade wheat flour was included for the sake of the comparison with the wheat flour series.

Flour	First count	Second count	Third count
First low grade	8	19	19
Rice flour	24	25	33
Barley flour	16	17	17
White rye flour	31	33	11
White corn flour	21	22	20

When rye meal was bolted through a No. 2 bolting cloth and the bran retained by the cloth was substituted for the first low grade wheat flour, the results were more decisive.

Flour	First count	Second count	Third count
Rye bran	40	33	35
Rice flour	19	17	18
Barley flour	9	11	7
Rye flour	14	21	10
Corn flour	19	17	18

In this series there is a rather definite percentage of choice so far as the rye bran is concerned. As with the wheat flours it is the coarse,

flaky material which is chosen by the beetles. But when cornmeal was introduced no choice for it was indicated. Unfortunately the experiments in which the cornmeal was included were not properly checked and will not be included here.

Since the above experiments seemed to indicate that coarseness was a factor in invasion, an experiment was tried in which the foods differed in respect to this factor, but were of the same nutritive value. The bran was sifted and that which was retained by a No. 2 bolting cloth was divided into two portions, one which was left in the original coarse condition, and the other which was ground until it would pass through a No. 5 bolting cloth. The fine material was placed in one half of a container and the coarse material in the other half while the beetles were placed in a depression in the center, as in the previous experiments. An average of 62 per cent of the beetles was found in the coarse material.

For a further check on the factor of coarseness, an experiment was planned to exclude the factor of nutrition. For this purpose pine sawdust, which had been treated with alcohol to dissolve out the oils, was employed. A coarse grade, which passed through a No. 0000 bolting cloth but which was retained over a No. 00 cloth was placed in one fifth of the jar and the other four fifths of the jar contained fine sawdust which passed through a No. 2 bolting cloth. The experiments were manipulated in the same manner as when the five grades of wheat flour were used. The results were surprisingly like those obtained with the wheat flours.

Material	First count	Second count	Third count
Fine sawdust No. 1	25	11	10
Fine sawdust No. 2	28	8	5
Fine sawdust No. 3	11	13	12
Fine sawdust No. 4	2	20	23
Coarse sawdust	34	48	49

These results make it evident that the coarseness of the flour or cereal may be the dominant factor concerned in invasion by insects. The fact that similar results were not obtained with cornmeal makes it seem evident that this factor is concerned with the tactile responses of the beetles. The beetles respond to the flaky materials between which they can penetrate very readily while the more granular material does not offer the same stimulus, because the finer particles fill in the spaces between the larger particles and thus offer much less favorable opportunities for the beetles to enter the material.

The influence of nutrition in determining the relative invasion of the wheat flours has not been measureable as a factor in these experiments. To determine whether the method would indicate differences of nutritive value, coarse sawdust was introduced in place of the bran in the wheat flour series and it was found to contain a varying number of beetles, principally at the edges where the sawdust and flour became slightly mixed. It averaged only 6 per cent of the beetles, which makes it very evident that the method used does measure the nutritive difference between the wheat flours and the sawdust.

When an experiment has stood for a period of several weeks it has been found that the decisive differences between the flaky and fine materials tend to disappear. Thus the ratio between the percentages of the coarse and fine bran material was 60 per cent and 40 per cent examined every 48 hours, but when the experiment was left for a period of 26 days it was found that the fine material, contrary to the previous findings, contained 53 per cent of the beetles and the coarse material contained 47 per cent. An examination of the material after it has been exposed to a large number of beetles for an extended length of time shows that it has been burrowed by the beetles until it is "honeycombed" and is apparently more attractive to the insects. The beetles may be driven by competition to enter the fine flour and thereby alter it and make it a more favorable environment resembling a flaky material so far as their tactile responses are concerned.

In consideration of the relative development of the beetles in the various wheat flours and the wheat flour substitutes, an attempt was made to determine whether there was a difference in the velocity of development in the various foods, and, if so, whether this difference was sufficient to account for more insects being found in certain of the foods than in others. The experiments were all carried out under controlled conditions and all of the experiments of each series were carried on simultaneously so that all of the results were directly comparable.

The first series was started by exposing the material to a number of beetles for twenty-four hours and then removing the beetles. Since no attempt was made to determine the sex of the beetles used, a definite number of eggs could not be expected, but from a dozen or more beetles, a few eggs could be depended upon. The vials containing the material and eggs were placed in the dark at a known temperature and humidity. The material was examined daily except when the task of making the records made it impossible for all of the material to be studied each day.

The date of hatching of the eggs is taken from the first daily ex-

amination at which larvae were observed. Thereafter the larvae were measured at each examination and the measurement of the head, at the point of its greatest width, and the total length of the larva were recorded.

The graphs (Plates II and III) are arranged in columns, with the records of the individual beetles placed one above the other in each column. The graphs of the beetles in the various foods are grouped together. The time in days represented by the vertical divisions of the chart, each large division representing ten days; and the stages of the life cycle of the beetles are represented by the horizontal divisions of the chart. The daily temperature is recorded at the top of each column of graphs.

The first day of the egg stage is represented by an open square, because the exact time of oviposition is not known within twenty-four hours. Thereafter the definite records are represented by solid black squares. Upon the appearance of the larva the record moves up one space to record the beginning of the next stage of the life cycle. At the time of each moult, as evidenced by the increase in the head measurement, the record moves up one space. At the end of the record the appearance of the adult is recorded with an "X." If the record of the emergence of the adult is not known within twenty-four hours, the "X" is placed in an open square.

When open squares are used in the records, they are placed hypothetically from a study of the complete records of other individuals. At the top of the record for each of the wheat flour groups, the record of the checks is shown. These beetles were subjected to the same conditions as the others except that they were not interrupted for the taking of measurements. Consequently the check records are straight lines and show only the duration of the entire life cycles.

It will be noticed that the records are very similar for the first twenty-two days and that the variations in the length of the stages come in the latter part of the larval life, particularly during the last instar. While there is considerable variation among the larvae feeding on the different wheat flours, it is to be noted that all of the checks are of the same length. The variations must, therefore, be attributed to other factors than the nutritive value of the food. The fall of temperature toward the end of the experiment will, of course, account for the prolongation of stages then incomplete, but would not account for the total difference between the long and short stages.

The records of the beetles fed on the wheat flour substitutes show the greatest variation, yet, even here, there are some individuals in

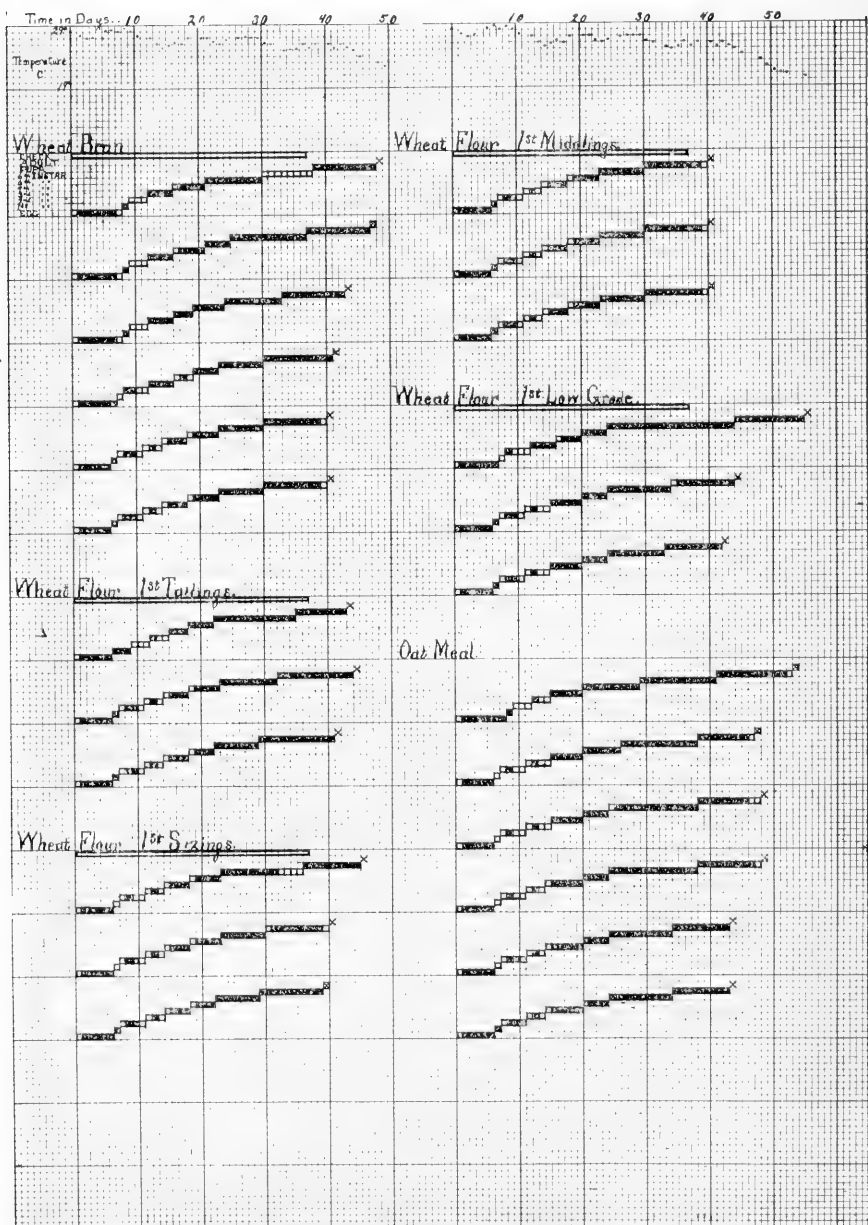


PLATE II

A graphic comparison of the length of various stages in the life cycle of *Tribolium confusum* under different food conditions. Temperature is indicated by the dotted line across the top of the plate. Time in days is indicated by the small squares, reading across the plate. The record of each beetle is recorded in the ten spaces between the

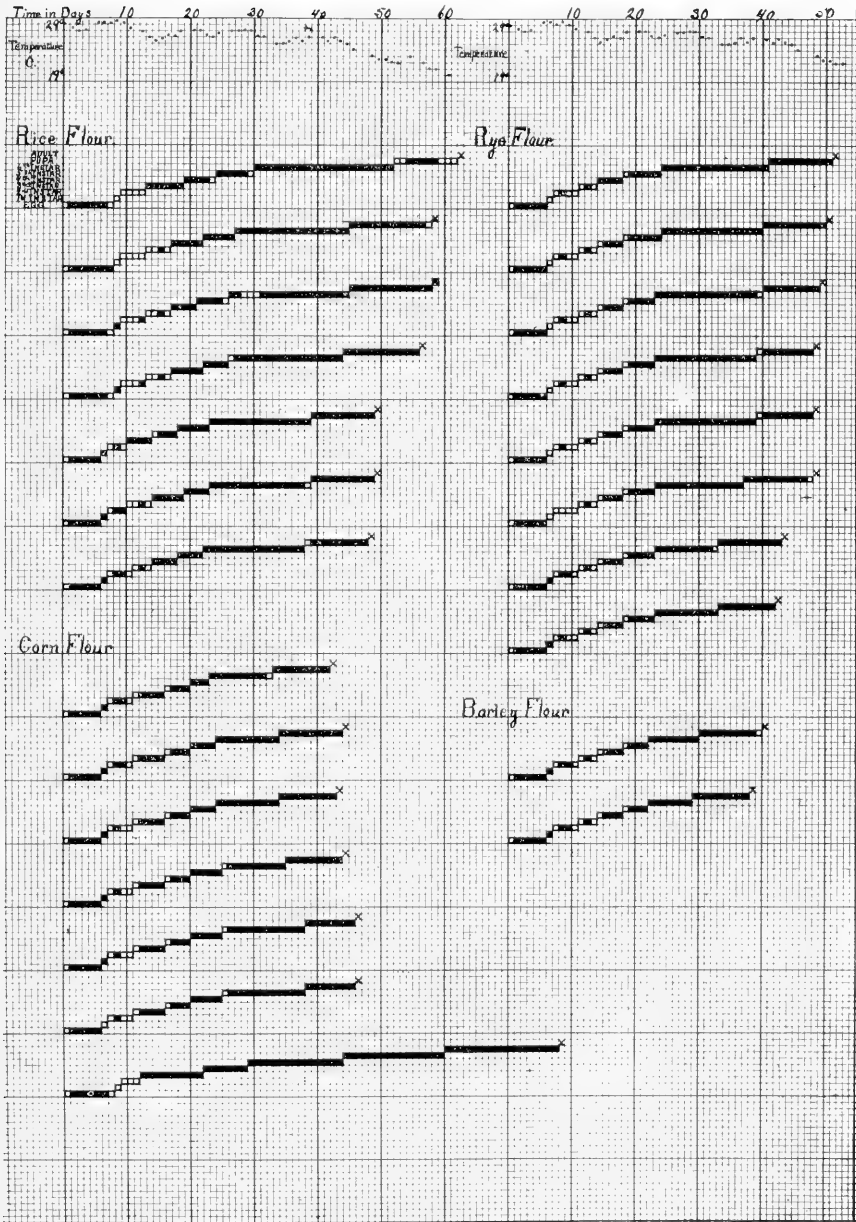


PLATE III

heavy horizontal lines. Each stage of the life cycle is indicated by a small square, starting with each heavy line and reading up the plate. The first square represents the egg stage, the next six represents the six larval instars, the eighth square represents the pupal stage, and the ninth square represents the emergence of the adult beetle.

each group which do not differ greatly from some of the individuals in the wheat flour groups. The group of beetles fed on rice flour show the greatest prolongation as a group, while the longest individual life cycle is found in the corn flour group.

Another series of experiments has been carried out at a temperature of 26°C in which the total length of the life cycle was recorded and no attempt was made to determine the length of the various stages. Here, as in the checks for the wheat flours of the first experiment, the records of the insects in the different foods are much more uniform. The time from the hatching of the eggs until the emergence of the first adult was 37 days in the middlings, 39 in the sizings, 38 in the low grade, 38 in the tailings, and 39 in the bran. In the other foods it was 39 days in the rye flour, 38 in the barley flour, 40 in the corn flour, and 47 in the rice flour. The shortest time in the rice flour was thus about 20 per cent longer than in the middlings. But all of the larvae in the rice flour had pupated by the end of 47 days while one of the larvae in the middlings was still feeding at the end of this period.

The rate of development of the beetles may be influenced by the relative fecundity of the beetles in the various foods. The number of eggs deposited by females which were restricted to certain foods have given the following results: middlings, 32; sizings, 34; low grade, 41; tailings, 32; bran, 20; barley flour, 50; rye flour, 20; corn flour, 45; rice flour, 12. The beetles studied have shown such an amount of variation among the different individuals that the limited data at hand cannot be considered sufficient for determining the influence of different foods upon fecundity. Such conclusions must await the completion of a series of experiments involving many individuals reared in certain foods for many generations.

The analysis of the factors influencing relative development will require a more extensive study, but there are certain facts which are brought out by the work thus far. There are individual variations which seem to be independent of the food on which the insects are feeding. It is possible that the different portions of the kernels which constitute the flours are unequally distributed in the mixture as it exists in market form and that some individuals, by chance, obtain a ration which accelerates growth, while other individuals, by chance, obtain a diet which is less favorable for rapid growth.

The observations show that, in general, the beetles with the prolonged stages encountered mechanical difficulties. They were found with particles of flour attached to them and all their efforts for

a time devoted to freeing themselves. Mortality in many cases seemed to be due to these mechanical difficulties.

From the records at hand the percentages of mortality are as follows: for the wheat flours, first middlings, 40 per cent; first sizings, 33 per cent; first low grade, 40 per cent; first tailings, 40 per cent; bran, 32 per cent; for the other materials, barley flour, 50 per cent; steele-cut oats, 32 per cent; rye flour, 55 per cent; white corn flour, 56 per cent; rice flour, 12 per cent. These percentages are taken from meager data and should not be looked upon as conclusive vital statistics, altho they are the result of controlled conditions which approximate the optimum.

METHODS OF CONTROL

The control of *Tribolium confusum* is the problem of preventing it from invading stored food products. In cases where the infestation already exists it may be necessary to resort to some method of "sterilizing" the infested products.

So little difference has been found in the susceptibility of the various food products studied in this connection that the number of insects which may be found in a given product probably depends very largely upon the opportunities which the beetles are afforded to invade the product. Flour on the floors of mills and storehouses supports a small population of beetles which invade sacks of flour and are then transported to other storehouses where the infestation may spread. Among the many instances of this which have been found was that of a large warehouse which had become badly infested from a single shipment of infested rolled rye. The flour which was stored closest to the rolled rye contained the heaviest infestation, and that more distant from it contained proportionately fewer beetles.

An infested storeroom or mill may be freed from insects by fumigation with hydrocyanic acid gas, or it may be heated to the fatal temperature for insects. Both of these methods have been described by Dean in Bulletin 189, Kansas State Agricultural Experiment Station, Manhattan, Kansas.

The fumigation should not be undertaken without detailed directions and the temperature conditions must be favorable. Furthermore it requires the shutting down of the mill for several days and always involves a certain amount of risk on the part of the operator. Dean also states that the gas does not penetrate the accumulations of flour and the cracks, which harbor the insects, so well as the heat does.

When heat is used to kill the insects in a building it is necessary

to obtain a temperature of 48°C (120°F) and maintain this temperature until the heat has penetrated all of the flour or grain which may contain insects. In Kansas it is possible to do this during warm summer weather, when there is a sufficient amount of radiation, by turning on the steam Saturday evening and keeping it on until late Sunday night. In this way the mill is cooled down by Monday morning and no time is lost. Experiments in Minnesota have shown that it is necessary to have increased radiation in order to attain the proper temperature. However, this would seem to be a promising field for experiments.

It has been found that infestations are often spread by the refilling of flour sacks which have not been thoroly cleaned. In several instances where storerooms were found to be free from any source of infestation the cause of the large number of beetles present in the flour was traced directly to the refilling of uncleaned flour sacks. When a method of heating the flour sacks in the oven was adopted, the trouble ceased. It was found that the empty sacks could be placed in an ordinary baker's oven at the usual temperature of 230°C (about 450°F) and left for about five minutes, when all of the insects would be killed, provided the sacks were not more than three layers deep. As a precaution against scorching of the sacks they should be placed on pans or boards to keep them from coming in contact with the oven. Care should also be used not to let the sacks remain in the oven longer than five minutes at the temperature indicated above. Boxes and other utensils which are used about a bake shop and which may harbor insects, have also been heated in the oven and all stages of insects killed.

Large amounts of flour or other stored food products may be freed from *Tribolium confusum* by fumigation or by sifting. Carbon disulphide or hydrocyanic acid gas (described above) may be used for this purpose. The carbon disulphide is placed in shallow dishes on top of the material to be fumigated and the liquid evaporates. The fumes, which are heavier than air, settle down into the material and kill all insects which may be present. This material is very inflammable when mixed with air and should never be used near a fire. The quantities recommended are about one pound to every 100 cubic feet of space. When the material is placed in a tight barrel, about one cupful of the liquid will be required. The receptacle must be tightly covered and left for a day or more, after which the material should be well aired. Farmers' Bulletin 799, United States Department of Agriculture, Washington, D. C., contains much information with regard to the use of carbon disulphide.

Sifting of flour will remove the beetles only when it is possible to pass the material through a bolting cloth which is fine enough to exclude all stages of the beetles. Experiments with the eggs of *Tribolium confusum* have shown that the size of bolting cloth which would retain them depended upon the material adhering to the eggs (Fig. 2).

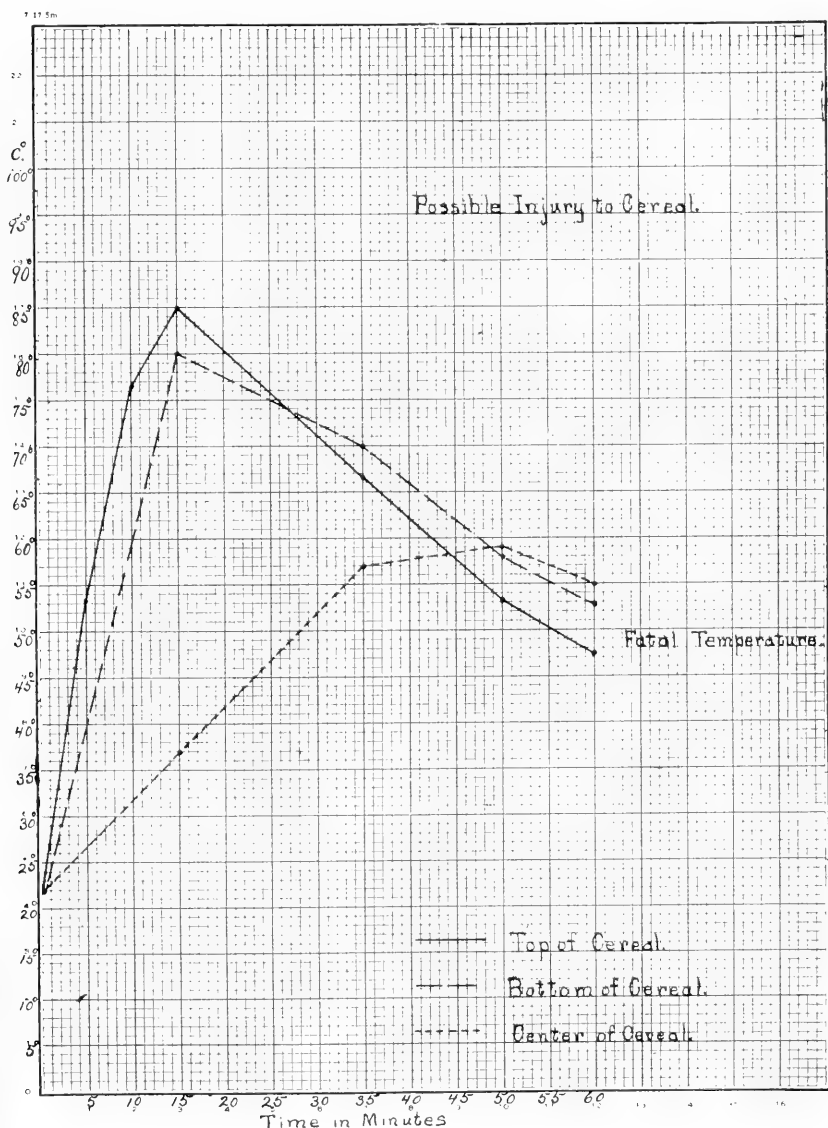


Fig. 15. Curves showing the rise of temperature in the top, center, and bottom of a pan of cereal heated in a gas oven. The oven was cold at the start, the cereal was two inches deep in the pan, and the fire was as low as it would burn for fifteen minutes.

Experiments in passing eggs through bolting cloths gave the following results:

No. 0 standard bolting cloth passed 11 eggs taken from ordinary wheat flour and retained 1 which was attached to some coarse material.

No. 1 bolting cloth—3 eggs were retained, 4 passed through readily, and 3 others were forced through without injury.

No. 2 bolting cloth—retained 5 coated eggs, and 1 naked egg was forced through endwise.

No. 3 bolting cloth—no eggs were passed through without injury.

The experiments with the larvae gave the following results:

No. 0000 bolting cloth—larvae of all instars passed through.

No. 000 bolting cloth—larvae of the first five instars passed through readily, 7 larvae of the sixth instar crawled through by exerting some force.

No. 00 bolting cloth—1 larva of the sixth instar passed through with great difficulty. Larvae of the fifth instar also required some effort to get through the meshes.

No. 0 bolting cloth—retained 1 larva of the fourth instar while 3 larvae of this instar and 3 of the fifth instar passed through, the latter with much effort.

No. 1 bolting cloth—1 larva of the fourth instar passed through, all others of this and succeeding instars were retained. The younger larvae all passed through.

No. 2 bolting cloth—2 larvae of the fourth instar passed through with great effort. Smaller ones passed through and the larger ones were retained.

No. 3 bolting cloth—2 larvae of the third instar passed through with great effort, all others of this instar were retained.

No. 4 bolting cloth—3 larvae of the third instar succeeded in passing through.

No. 5 bolting cloth—3 larvae of the third instar passed through with effort as before.

No. 6 bolting cloth—1 larva intermediate between the second and third instars, passed through, 6 larvae of the second instar were retained.

No. 7 bolting cloth—retained 2 larvae of the second instar and 5 passed through after a struggle.

No. 8 bolting cloth—1 larva of the first instar succeeded in getting through, while all others were retained.

It is evident that larvae may pass through any bolting cloth coarser than No. 6 and that No. 9 must be used to be absolutely safe. This

means that sifting will remove the beetles from only the higher grade flours. It also indicates that in the process of milling eggs or young larvae might be included in the coarser and lower grade flours while they might be excluded from the finer, high grade flours.

For small amounts of flour the safest and simplest method is to heat it in the oven. This may be done by placing the flour or cereal a little less than two inches deep in pans and keeping the fire as low as it will burn well until the surface of the cereal reaches a temperature of 85°C (185°F). If a gas, gasoline, or kerosene stove is used, the fire should be turned out and the oven left closed for thirty minutes after the above temperature has been reached. If a wood or coal stove is used, the oven door should be left open and the fire kept as low as possible during the thirty minutes after obtaining the desired temperature. It is necessary that the fire should be kept low in order to allow as much time as possible for the heat to penetrate to the center of the cereal before the top or bottom of the cereal reaches a temperature which will injure it. It has been stated that some materials will be injured if heated to 96°C.

Stirring the material when it has reached 85°C helps to distribute the heat. Figure 15 shows the curves for the temperatures of the top, bottom, and center of a pan of cereal heated as described above. It will be noticed that it required fifteen minutes for the top of the cereal to reach a temperature of 85°C. The temperature of the bottom of the cereal follows that of the top, while the temperature of the center lags behind. But even the temperature of the center passes well above the fatal temperature for the beetles, which is about 48°C. At the same time the top of the cereal does not reach the temperature which will injure it.

When the heat treatment is followed by careful storing in tight, clean containers, the possibility of loss due to *Tribolium confusum* is eliminated. The heating of all cereals as soon as they are brought into the house, in warm weather, is strongly recommended. Eggs or small larvae may be present in the cereal when a close search fails to reveal them, and a little time spent in heating the cereal will eliminate the danger of infesting the home. It is much easier to keep the beetles out than it is to get them out if they once get in.

If a suitable thermometer is not at hand, a heat testing wax is on the market which is standardized to melt at the proper temperature. If the grocer does not have the wax he may get it from his wholesale dealer. A box of the wax costs only five cents and contains nearly a year's supply.

SUMMARY

1. The larval life of *Tribolium confusum* is composed of six instars which may be distinguished by the measurement of the head at its widest point.

2. A method of examining flour or cereal to determine the amount of infestation, has been adopted which makes it possible to express the results in terms of the beetles in a given weight of flour. For this purpose the sample of flour is taken from the sack by means of a brass tube which may be thrust in between the stitches at the end of the sack. The sample of flour withdrawn is then weighed and sifted through a bolting cloth and the residue retained by the bolting cloth is incubated to determine whether any eggs are present. The number of insects present may be expressed by a computation of the number per kilogram of material.

3. A study of the relative susceptibility of various wheat flours and wheat flour substitutes by means of a jar with removable partitions, has made it possible to determine the number of insects attracted to each of a number of flours used in the experiment. The results of this method make it seem that coarse flaky material is slightly more attractive than fine or granular material. However, by crawling through a fine flour the beetles cause it to become honeycombed and thereafter the beetles enter it as readily as they do the coarse flaky material.

4. A comparison of the rates of development of beetles in various foods, under uniform conditions, has shown that the life cycle may be slightly longer in some foods than in others and that this difference in the rate of development is confined very largely to the last larval instar.

5. The differences in the relative infestation which workers have noticed in mills are not accounted for by the experimental methods employed in this work but it is suggested that these differences may be due to the methods of handling various products which give the beetles a better opportunity to enter some of them than others.

6. Materials which have passed through a No. 3 bolting cloth will contain no eggs. To exclude the larvae of the first instar a No. 9 bolting cloth must be used.

7. The heating of flour sacks before they are refilled has been found to control the beetles, when accompanied by a general practice of cleanliness about storerooms.

8. A convenient method has been devised for treating small amounts of flour to kill any eggs or other stages of insects which may be present. It has been found that when flour is less than two inches deep in pans, it may be slowly heated in an oven until the surface of the flour reaches a temperature of 85°C and then, after remaining in the oven for thirty minutes longer with the heat turned off, the flour will have attained a minimum temperature well above the fatal temperature for the beetles while the maximum temperature is well below one which will cause injury to the cereal.

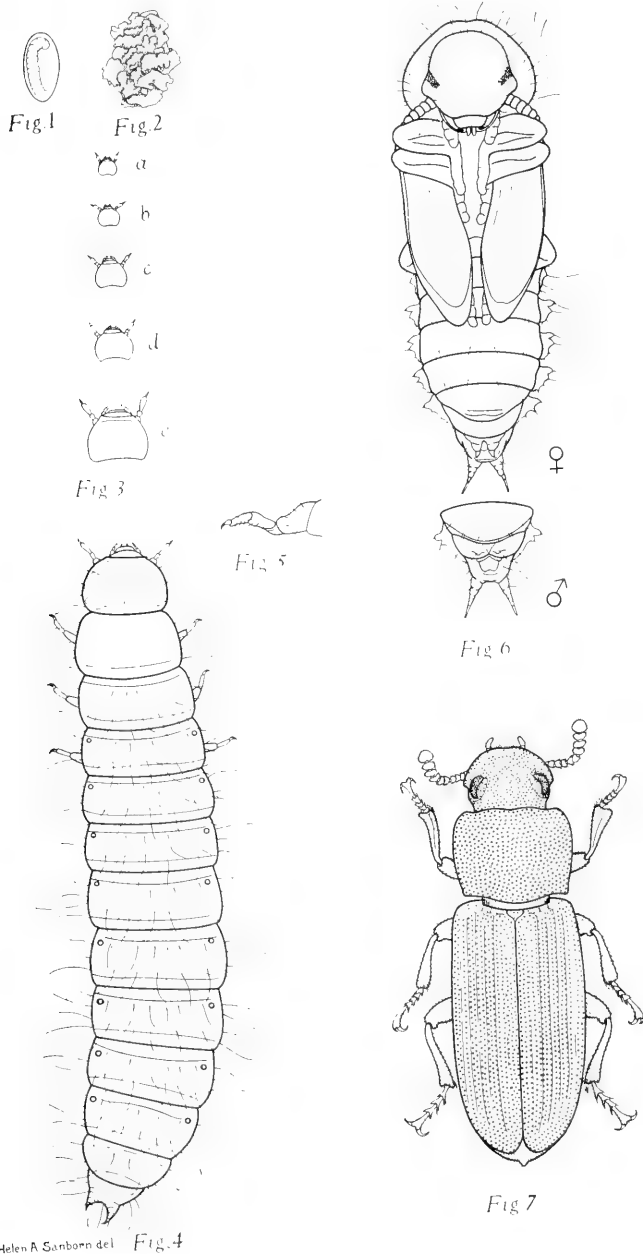


PLATE IV

- Fig. 1. Naked egg. x17.
 Fig. 2. Egg coated with flour. x17.
 Fig. 3. Heads of larvae of first, second, third, fourth and fifth instars. x17.
 Fig. 4. Mature larva of the sixth instar. x17.
 Fig. 5. Larval leg.
 Fig. 6. Female pupa and terminal segments of male pupa. x17.
 Fig. 7. Adult *Tribolium confusum* Duval. x17.

THE CLOVER-SEED CHALCID¹

Bruchophagus funebris Howard

BY WARREN WILLIAMSON

The clover seed chalcid first attracted the attention of entomologists in 1879 when Prof. J. H. Comstock at Washington, D. C., reared it from clover heads infested with the clover seed midge, *Dasyneura legumini-cola* Lint. He believed it to be parasitic upon the latter species. Specimens were submitted to L. O. Howard who described it as a new species, naming it *Eurytoma funebris*. Dr. W. H. Ashmead in 1894 referred the species to a new genus which he named *Bruchophagus*, believing all the species of this genus to be parasitic on the seed weevils, *Bruchidae*. Evidently the clover seed chalcid was generally considered as a parasite until Dr. A. D. Hopkins (1898), in West Virginia, proved that instead of being a parasite, it is itself a serious clover seed pest.

Other workers whose publications have contributed much to our knowledge of the subject are R. H. Pettit of Michigan, E. G. S. Titus of the Bureau of Entomology, who collected data on the distribution of the pest as well as contributing other important data, F. M. Webster, Bureau of Entomology, who published the first illustrations, Dr. J. W. Folsom of Illinois who gave the most complete account of the species yet published, and T. D. Urbahns who gave, in Farmers' Bulletin 636, the most recent account of original work with control methods.

The study of the clover seed chalcid in Minnesota was begun in 1907 by A. G. Ruggles and continued by him until 1910 when T. D. Urbahns had charge of the investigations for one year. The work of the writer was begun in July, 1911, but after 1914 it was so frequently interrupted by others duties that it was finally discontinued altogether.

DESCRIPTION OF INSECT

The following description of the different stages is quoted from Folsom (1909).



Fig. 16. Clover head showing openings made by adult chalcids in emerging.

¹ Published with the approval of the Director as Paper No. 155 of the Journal Series of the Minnesota Agricultural Experiment Station.

“The adult is a minute, compact, flylike insect mostly black, but with parts of the legs yellowish brown. It is small, the female being 1.9 mm. in length and the male 1.7 mm.—yet its actions on a clover head are so characteristic that one who has made the acquaintance of the insect can recognize it at once. Apart from its natural surroundings, however, one must look to certain minute details of structure in order to determine the species.

“In the genus *Bruchophagus* the marginal vein is linear and not longer than the stigmal vein; the mesonotum is umbilicately punctate and the abdomen ovate, pointed, and compressed in the female. The male resembles the female but lacks the point to the abdomen and the abdomen is shorter than in the other sex; while the male, unlike the female, has oval funicle segments and long antennal hairs.

“The male of this particular species, *funebri*, is black and non-metallic. Eyes dark brown, antennae almost as long as the thorax; flagellum of eight segments, there being five in the funicle and three in the club; the funicle segments have each a short apical peduncle, and all but the first of these segments

have either two or three whorls of yellowish hairs—usually three on the second segment of the funicle and two on segments three to five. The knees, anterior tibiae, and all the tarsi are light yellowish brown. The stigma of the wing gives off a feeble branch. The abdomen, joined to the thorax by a short, stout peduncle, is small, being less than half as long as the thorax, and its fourth segment is the largest.

“The female is like the male in coloration but is larger, with these



Fig. 17. Female chalcid ovipositing.

distinctive characters. Antennal segments not petiolate, and without the long hairs; flagellum of nine segments, the funicle having six and the club three. Abdomen not pedunculate, longer than the thorax, with the fourth and fifth segments short and subequal, and with a light brown pointed extremity—a part of the ovipositor.

“The egg is broadly elliptical to ovate in form, ending anteriorly in a small papilla and prolonged posteriorly as a slender tube, at least twice as long as the egg proper, which averages 0.26 mm. in length. The egg when laid is translucent, whitish, and smooth; within a day, the appendage shrinks and turns brown.

“The maggot-like larva is white, stout, footless, with a small head; length when full grown, 1.5 to 2 mm. The larva shows few distinctive characters, tho it is stouter and less active than parasitic larvae of the same family.

“The pupa is for a time white, but darkens as the color of the imago develops; length 1.9 mm.”

It may be noted in addition to the above description of the larva that when very young and feeding upon green seed contents, it has a greenish tinge. The full grown larva has brown mandibles, each with a tooth on its inner edge.

SEASONAL HISTORY AND HABITS

The life history of *Bruchophagus funebris* consists of two generations in a year with overlapping individuals producing a frequent third generation. The first brood of adults appears in June. Females oviposit in the soft green seeds of the first crop and of stray clover plants along roads. The time required for the eggs to hatch varies. Accord-

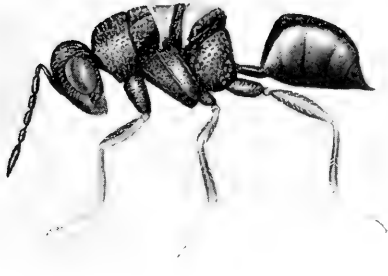


Fig. 18. Male of *B. funebris*.



Fig. 19. Egg of *B. funebris*.

ing to Urbahns (1914), under favorable temperatures the larvae begin feeding in about a week after the eggs have been deposited. If conditions are extremely favorable, the larvae complete their growth in about twelve or fourteen days, enter the pupal stage for four or five days and emerge as adults. The larval and pupal stage are spent entirely within the infested seed. The second and a partial third brood overlap in July and August. Females oviposit in the late blossoms or seed crops. A few of these become adult before winter, but soon perish. They hibernate mostly as full-grown larvae within the seeds, enter a short pupal stage in the spring and appear as adults in June.



Fig. 20. Mandibles of *B. funebris*.

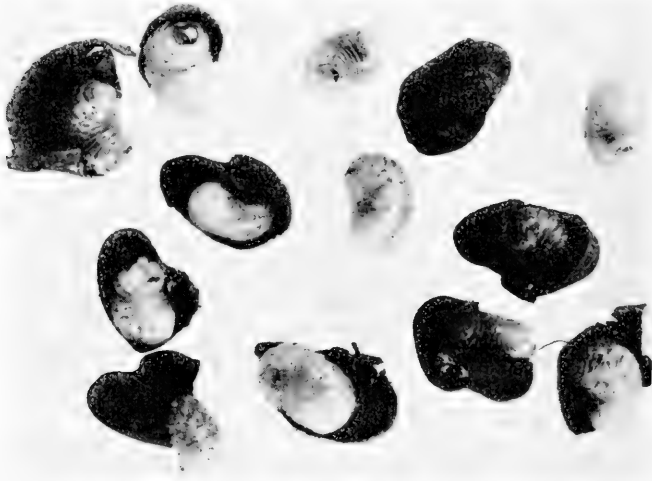


Fig. 21. Larvae of *B. funebris* in clover seeds. (After Urbahns.)

EMERGENCE OF ADULTS

In 1911 the clover seed chalcid was very rare in the southern half of Minnesota owing to the failure of the clover crop on account of the unusually dry season. Observations were made in the vicinity of Duluth from July 15 to October 15. Adult chalcids were not found until July 21. They reached their maximum abundance about August 15, then gradually decreased in numbers and were not found in the fields after September 25. A few specimens were found at Bemidji, September 21.

In 1912, the weather conditions being favorable for the growth of red clover, the chalcids got another start in the southern half of the state. The first specimen was taken June 1 at University Farm, Saint Paul. This undoubtedly represented the first generation for the year. So few could be found that we cannot say when this generation reached its maximum abundance. The second generation appeared in breeding cages on July 5, emerging rapidly until July 9, then slowly and in small numbers during the remainder of the month.

In 1912, also, observations and collections were made in the southeastern part of the state, Olmsted and Fillmore counties. No data were secured on the emergence of the first generation. Clover heads collected in that region on August 8 and 9 and placed in the insectary at University Farm gave adults from August 19 to September 27. Heads collected September 11 and 12 gave adults from September 24 to November 16. In all, 217 individuals were reared, two-thirds of which emerged before September 1, and these came from the heads collected August 9 and 10. The period of most numerous emergence for the year in Olmsted and Fillmore counties was probably during the last week of August.

In Wadena county, in 1912, we were not able to observe the emergence of the first generation, but from breeding cage records and field collections it appears that of the succeeding generation a very few adults were out from August 15 to 25, then a rapid increase, a large number emerging until September 25, then a rapid falling off in early October.

In the season of 1913 in the vicinity of University Farm, adults appeared June 12, a very few until June 18, then no more until July 10. A few appeared during July and until August 18 when there was a sudden increase and many emerged until September 6. After that a few during the remainder of the month. Clover heads taken in the previous September in Fillmore and Olmsted counties gave the first adult June 12 and the last July 1. The period of most numerous emergence was from June 17 to June 21.

Clover heads from Wadena county collected in September, 1912, gave adults in 1913, at Saint Paul, from June 11 to July 5. Nearly all of these appeared between June 17 and July 1, with the maximum emergence on June 21.

In November, 1912, clover heads were collected at Duluth, St. Cloud, Winona and Mankato. Adults emerged in 1913 as follows:

- Duluth specimens, June 9 to July 1, maximum emergence, June 18.
- St. Cloud specimens, June 12 to July 1, maximum emergence, June 18.

Winona specimens, June 12 to July 5, maximum emergence, June 16.
Mankato specimens, a few on June 17, no others emerging.

Second generation adults from Lewiston, Winona County, began to emerge July 2, 1913, and reached their maximum July 10. None emerged after July 23.

A lot of heads collected at Monticello, Wright County, July 24, 1913, gave adults from August 9 to 25, about two thirds of these emerging from the 14th to the 16th.

In 1914, at Saint Paul, adults were first found in the field June 2. The time of most abundant emergence of this first generation was June 10. Second generation adults were on the wing June 29. Emergence continued in varying abundance until October 2. Three periods of considerable abundance were noted, about June 10 as before stated, then the last week of July and again the first week of September.

Our earliest seasonal record of emergence is May 25. This was from a lot of clover heads taken at Lewiston, Winona County, September 19, 1913. From these 2,716 adults emerged between May 25 and July 21, 1914. The majority came out early in June. Maximum emergence between June 6 and 9, 809 adults.

In connection with these data it should be noted that T. D. Urbahn while working at this station reported the following: "Seeds collected in October of 1909 and kept in a cold room all winter produced adults of the seed chalcid all through June of 1910. In the season of 1910 adults appeared in the field with the first clover blossoms about June 1. They increased rapidly until about June 15, after which a rapid falling off in their numbers took place. About June 20 to June 30 adults of this species could hardly be found. With the beginning of July they began to increase in numbers and by August 10 they had reached their maximum abundance for the year. Late in August the adults of this species rapidly disappeared with the drying of clover blossoms in our dry season."

To summarize: Adults of the spring generation appear early in June, sometimes late in May. They reach their maximum abundance from about June 9 to June 18. Most of these are out in June but a few may not emerge until as late as the third week in July. Adults of the succeeding generation may be found from early in July until October. The largest numbers are found from about August 10 to 15 and again in the first week in September.

DISTRIBUTION

The clover seed chalcid appears to be widely distributed over the United States, altho southern records are few. In Minnesota it is recorded from Duluth, Hinckley, Meadow Lands, Detroit, Bemidji, Audubon, Fergus Falls, Wadena, Verndale, St. Cloud, Park Rapids, Itasca Park, Monticello, Windom, Worthington, Owatonna, Winona, Montgomery, Mankato, Chatfield, Lewiston, Stewartville and in and around Saint Paul and Minneapolis. As to foreign distribution, we quote from Urbahns (1914) "Injury from this insect has been observed in cultivated alfalfa seed imported from Germany, Turkestan and Chile, and in both the cultivated and uncultivated varieties of alfalfa seed from Turkey and Siberia."

FOOD PLANTS

As before stated, when it was discovered the species were reared from heads of red clover, *Trifolium pratense* L., altho at the time its true relation to the plant was not recognized. In the eastern part of the United States and in this section red clover seems to be the favorite food plant. The mammoth variety is infested as well as the medium. Crimson clover, *Trifolium incarnatum* L., also is subject to attack and it is interesting to note that it was from seeds of this plant that specimens were reared by Hopkins (1898) when he discovered the real feeding habits of the species.

While it received the name it bears because it was first observed infesting the seeds of red clover, more recently it has become an even worse pest of alfalfa seed in the region where this crop is grown to a large extent. Bur clover, *Medicago hispida* Gaertn., is another food plant.

Apparently the chalcid does not attack white clover, alsike, and sweet clover. This statement is based on the fact that we have often looked for it on these plants and have never found it, and have always got negative results when attempting to breed the species in cages containing seeds of white clover, alsike and sweet clover.

On July 30, 1912, observations were made on a female chalcid confined in a shell vial containing a head of red clover in full bloom. It crawled over many of the florets, touching each repeatedly with its antennae. It thrust its ovipositor into several of them, usually into the side through the calyx tube. When it could not do this on account of the crowded condition of the florets, it would stand on the top, inserting its ovipositor into the mouth of the corolla. The red clover head was removed and the insect was tried with sweet clover and then with

white clover, but it gave no attention to either. Then it was given the red clover again with the same results as before. Altho no egg was found when the red clover seeds were dissected immediately afterward, the behavior of the insect may be considered as strongly supporting the other evidence that the chalcid does not oviposit in the seeds of sweet clover or white clover.

NATURE AND EXTENT OF INJURY

The damage is done by the larva inside the seed devouring its contents. In most cases this work is so thoroly done that nothing is left but the seed coat. An affected seed still containing the insect can usually be distinguished from a healthy seed by its dull brown color, lack of luster and slightly shriveled or otherwise misshapen condition. Moreover an infested seed can be crushed in the fingers while a sound seed is hard. A seed from which the insect has emerged is an empty shell with a hole in one side through which the adult made its escape. If the adult emerges before the seed has been hulled or shattered out of its receptacle, a hole may also be made in the latter. In the case of emergence from a clover seed a hole will frequently be made through the side of the corolla. An adult coming from an alfalfa seed will make a hole in the pod directly over that in the seed. The plant itself is apparently not injured and the only way to detect the presence of the larva is by examination of the seed.

While the damage to the seed crop by the depredation of this pest has been very great, in many cases the growers have either not suspected their loss or, when they have, being ignorant of the real cause have attributed the shortage in yield to weather or soil conditions or to the work of the midge. Empty seed coats from which the adults have emerged are blown out with the chaff from the huller and thus escape notice. Many of the seeds containing larvae, being as heavy as normal seeds, may go into the bins with the latter, so that if the owner does not recognize them, as many do not, he will overestimate the value of the yield.

Counts made of infested seeds give some striking results. Folsom (1909), writing of conditions in Illinois, states that out of 49 clover seeds taken at random, 14 were found to be injured. Titus (1904) reports injury to the extent of 40 to 83 per cent with an average of 50 per cent to the head. Presumably his data were secured near Washington, D. C. Concerning the extent of injury to the alfalfa seed crop, Urbahns (1914) says that in samples collected from different localities, 10 to 30 per cent of the seeds of early crops and 20 to 70

per cent of those of late crops were found to be destroyed by this insect. He examined several samples showing damage to the extent of 85 per cent. Speaking of the money loss, he says that it varies on different farms from \$5 to \$60 per acre.

A. W. Morrill states, in the third annual report of the Arizona Horticultural Commission, that in the Buckeye valley the destruction of alfalfa seed by the chalcid ranges from 30 to 60 per cent, entailing an annual loss of \$300,000.

According to Swenk (1913), the loss to the alfalfa seed crop in 1911, in Red Willow County, Nebraska, was 80 per cent.

T. D. Urbahns while employed at the Minnesota station examined many samples of red clover seeds to determine the amount of infestation. One record which we select from his notes relates to a lot of 2,183 seeds collected in the field during the summer of 1910. Of these, 856 seeds were infested, or 39.2 per cent. Quoting from his notes: "Estimating the average crop of clover seed under the present (1910) conditions to be 150 pounds per acre, and this being at a loss of 39 per cent, the yield in the absence of *Bruchophagus funebris* would have been 246 pounds per acre. The seed chalcid is responsible for destroying 96 pounds per acre."

The destruction of 96 pounds of clover seed per acre would mean a money loss to the grower of \$18 to \$20 per acre at the present time.

METHODS OF CONTROL

The most common practice where red clover is grown for seed is to cut the first crop for hay and the second crop for seed. If the first crop is left standing too long, that is, until the heads are ripe, the eggs laid in the seeds by the first generation of adult chalcids will have a chance to develop and produce the adults which lay their eggs in the seeds of the second crop.

It was first suggested by Webster (1906) and afterwards recommended by Folsom (1909) that the same treatment employed against the midge be used in combating this insect also. Early cutting of the first crop would prevent oviposition to a great extent. If any eggs or young larvae were present, they would die with the drying of the undeveloped seed. Under this treatment the summer generation of chalcids would be greatly forestalled while the seeds of the second clover crop would mature early and most of them would be too hard to receive the eggs of any chalcids that might appear. Clipping back

the first crop or pasturing it lightly in the spring has been recommended also.

In order to test some of the measures suggested, several field experiments were carried on. In some of these the infestation was so light that no conclusions can be drawn from the results. Others, more conclusive, are reported below. The percentage of infestation given in each case is computed on the basis of 1,000 seeds taken at random from different parts of the experimental plot.

Mr. Chris Schultz, Simpson, Minnesota, allowed us the use of his field for co-operative experiments in 1912. Two plots of 2 acres each were used, having a uniform stand. They were treated as follows:

Plot I.

Clipped back with the mower, May 31.

Cut for seed, September 2.

Infestation, 1/10 per cent. Yield per acre, about 1 bushel.

Mr. Schultz reported that the seed in this plot was brighter and healthier in appearance than the seed from Plot II.

Plot II.

Cut for hay, June 25. Heads fresh in bloom and pink.

Cut for seed, September 25.

Infestation, 2 per cent. Yield per acre, about 1 bushel.

Another plot was to have been used for late cutting of the hay but it was cut early by mistake.

In 1912 also co-operative experiments were conducted on the field of Mr. Joseph Jackson, Verndale, Minnesota. Four 4-acre plots of uniform stand were treated as follows:

Plot I.

Cut for hay, June 14. Heads pink and green.

Cut for seed, October 4.

Infestation, 1/5 per cent.

Plot II.

Cut for hay, June 22. Heads all pink.

Cut for seed, October 4.

Infestation, none.

Plot III.

Cut for hay, June 26. About half of heads turning brown.

Cut for seed, October 5.

Infestation, 3 per cent.

Plot IV.

Cut for hay, July 26. Heads all brown.

Cut for seed, October 5.

Infestation, 3 1/3 per cent.

Owing to the inability of the owner to get a clover huller, a threshing machine was used and this did such poor work that it is impossible to give an accurate report of the yield.

In 1913 P. C. Daley, Lewiston, Minnesota, allowed the use of his field for co-operative experiment. Three plots of one acre each were selected, these having a uniform stand. They were treated as follows:

Plot I.

Clipped back, June 1.

Clipped again, July 1.

Cut for seed, October 1.

Infestation, 16.7 per cent. Yield per acre, 87 pounds.

Plot II.

Cut for hay, July 15. Heads all ripe.

Cut for seed, October 1.

Infestation, 31.7 per cent. Yield per acre, 38 pounds.

Plot III.

Cut for hay, July 3. Most of heads turning brown.

Cut for seed, October 1.

Infestation, 17 per cent. Yield per acre, 34 pounds.

In 1914 red clover was available for experimental purposes at University Farm, Saint Paul. Two plots were used, No. I being on series 6, Field E, and No. II on series 7, Field E. Each plot was 130x132 feet. They were treated as follows:

Plot I.

Cut for hay, June 17. Heads pink.

Not cut for seed because of severe infection of clover rust, *Uromyces trifolii*.

Ripe heads collected October 23 and seeds examined for larvae of clover seed chalcid.

Infestation, 2 per cent.

Plot II.

Cut for hay, July 17. Heads all brown.

Not cut for seed because of clover rust.

Ripe heads collected October 23 and seeds examined.

Infestation, 8 per cent.

It is evident from these results that early cutting of the first crop reduces the amount of infestation in the second crop sufficiently to make it a valuable preventive measure.

Attention must be given also to first-year red clover in the seeds of which the chalcid may breed and be carried over the winter to infest the crop of the second year. Clipping off the heads or pasturing can be recommended in this case. Volunteer clover, being almost always infested by the chalcid, should be kept down as much as possible.

PARASITES

Three species of parasitic chalcids have been found attacking *Bruchophagus funebris*. One of these, *Tetrastichus bruchophagi* Ashm. is described to considerable length by Urbahns (1917) but it has not been observed by the writer. The other two species have been found in our study of *Bruchophagus*, (1) *Habroclytus medicaginis* Gahan. We quote Gahan's description of the adult.

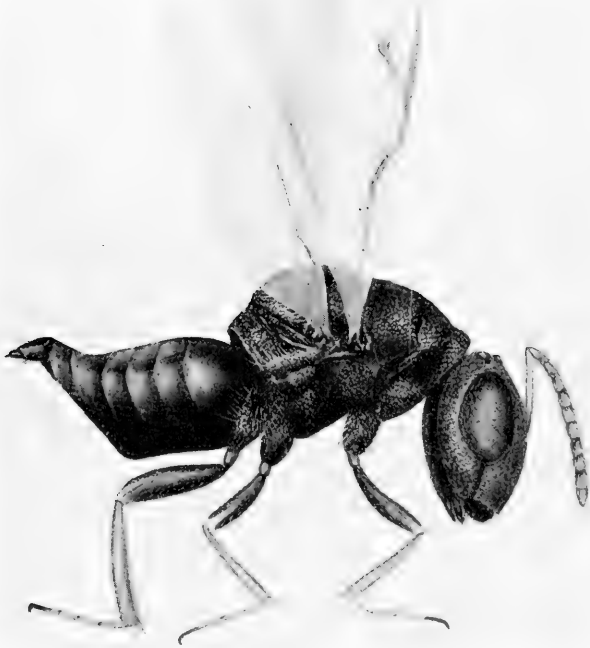


Fig. 22. Female of *H. medicaginis*.

Female—Length about 1.7 mm. Head and thorax closely punctate, the punctures on the medial portion of the mesoscutum slightly larger than those on the scapulae and scutellum; antennae with two ring-joints; pedicel and first funicle joint, excluding the ring-joints, about equal; following funicle joints a little longer than the first and a trifle

longer than broad; viewed from in front the head is broader than long, the clypeal region with converging striae and a deep median sinus on the anterior margin; viewed from above, the head is slightly broader than the thorax, narrow anteroposteriorly, the occiput slightly concave, the ocellocular line longer than the lateral ocellar line, the lateral ocellar line not equal to half the postocellar line; pronotum strongly transverse with a sharp margin anteriorly; propodeum short, without a neck, with a median carina and lateral folds, the region between the lateral folds

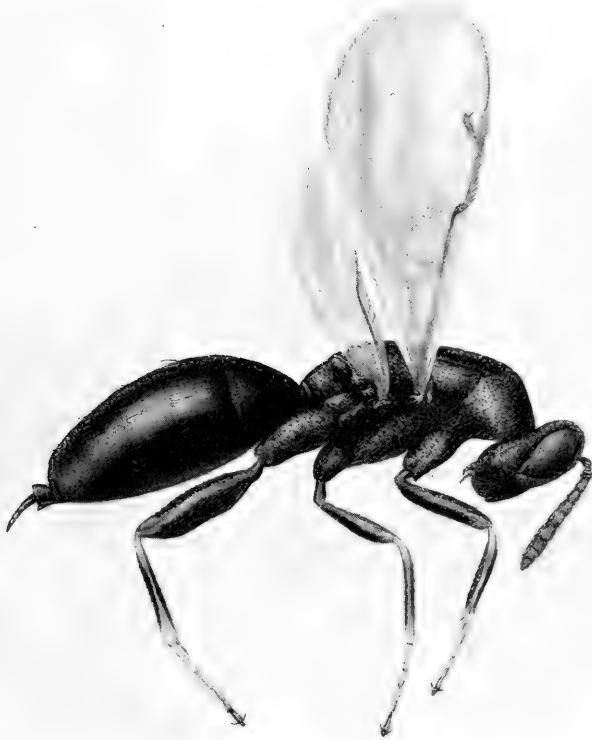


Fig. 23. Male of *I. longfellowi*.

more or less distinctly wrinkled and with a fovea-like depression at the base and another at the apex of the fold; the region outside the lateral folds is usually more faintly sculptured with indistinct lines; propodeal spiracles elliptical; marginal and post-marginal veins subequal, the stigmal one-third shorter; abdomen conic-ovate, about as long as the head and thorax and nearly smooth, the dorsal segments beyond the

first with very faint transverse lines. Head and thorax aeneous; antennae brown, the scope slightly paler beneath; wings hyaline; all coxae aeneous like the thorax, all trochanters and femorae black with an aeneous tinge; tibiae and tarsi usually reddish yellow, the former often brownish except at apex; apical joint of all tarsi dark; abdomen polished aeneous.

Male—unknown.

(2) *Idiomacromerus longfellowi* Girault. This species was discovered in the larval stage in a seed of red clover where it had eaten a larva of *B. funebris*, leaving only the empty skin mandibles. It was reared to the adult. After a number had been reared and collected in the field several specimens were submitted to Mr. A. A. Girault (1917) who described the species as new. His description of the adult is as follows:

"7 mm., with ovipositor two thirds longer. Like genotype but hind femora simple, compressed, head somewhat longer, longer than wide, antennae at eye ends, thus lower. Green, wings with an oblique, twice longer than wide, stain, caudo-proximad from apex of stigmal. First tibiae save near base, straw; knees, tip of tibiae and tarsi 1-3, white. Eyes nearly naked. Body densely, very finely scale punctate. Propodeum plane, not long, with foveae at cephalic margin between spiracles. Pedicel twice longer than wide at apex, ring joint 2 wider, shorter than 1, a third the length of funicle 1 which is nearly twice wider than long, others a little longer. Mandibles tridentate, teeth subacute, not large. Stigmal with slender neck. Venation as in genotype. Male same, nearly."

Larva. Grublike, nearly white, moderately pubescent, 1.5 mm. long. All body segments distinct. Dorsum of abdomen with segmental folds. Head with two conspicuous brown tubercles. Mandibles brown, acute, not dentate. After expulsion of intestinal contents, preparatory to pupation, the body becomes a clearer white and more flat in form.

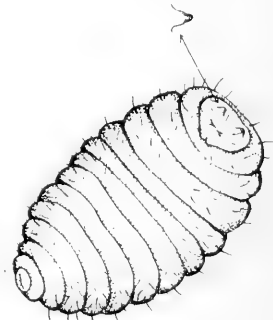


Fig. 24. Larvae of *I. longfellowi*.

Pupa. At first yellow, the abdomen being paler than the head and thorax. Sclerital sutures brown. It gradually becomes darker, and just before changing to the adult, it is black with green reflections. Eyes reddish brown. The pupal period of a specimen observed during May was thirteen days.

Efficiency of the Parasites. The following figures are taken from our notes. A lot of alfalfa pods collected when ripe gave in the insectary 151 adults of *B. funebris* and 165 of *H. medicaginis* which means that over 52 per cent of the *Bruchophagus* larvae were destroyed. *I. longfellowi* did not appear in this lot, altho we have found it in alfalfa at other times but never so numerous as the other species. In a lot of red clover seeds, which gave in the breeding cage 1,216 adults of *B. funebris* and 176 parasites, the latter comprised 156 of *I. longfellowi* and 20 *H. medicaginis*. In another lot of red clover seeds there emerged 937 *B. funebris*, 86 *I. longfellowi* and 14 *H. medicaginis*.

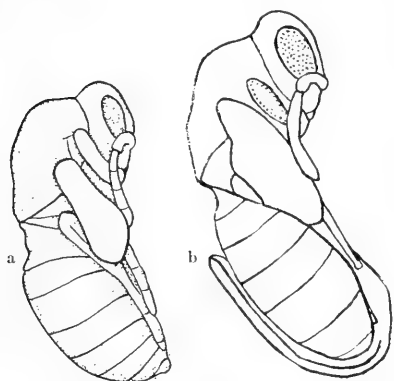


Fig. 25. a. Pupa of male *I. longfellowi*.
b. Pupa of female *I. longfellowi*.

From a lot of alfalfa pods we reared 151 adults of *B. funebris* and 165 adults of *Habrocytus medicaginis*. If we assume that each parasite emerging represents one *Bruchophagus* larva destroyed, then the original number of *Bruchophagus* larvae was 316, of which over 52 per cent had been killed by the parasite.

SUMMARY

The clover seed chalcid, at first thought to be parasitic on weevils infesting seeds, is now recognized as one of the worst pests of clover and alfalfa seed.

The adult is a small, black, wasp-like four-winged fly easily mistaken for a gnat by one not familiar with it. The egg, which is invisible to the naked eye, is deposited in the soft green seed of clover or alfalfa. The larva hatching from it is white and maggot-like, filling the empty shell of the seed when it is full grown. The pupal stage is of short duration. The adult in emerging gnaws a hole through the seed shell and escapes. At least two generations appear during the year. The species hibernates in the larval stage inside the seed.

The clover seed chalcid is found throughout most of the United States. In Minnesota, it appears to be present wherever clover is grown. It is found also in Germany, Turkestan, Chile, Turkey and Siberia.

The first adults appear in June. They are most abundant about the middle of August and are numerous again in the early part of September. A few may be found until October.

The food plants are red clover, mammoth and medium, crimson clover, bur clover, and alfalfa. Alsike, white clover and sweet clover are apparently immune.

The injury is caused by the larvae devouring the contents of the seed. The greatest amount of damage to clover seed recorded in Minnesota is 39 per cent. In other sections of the country, especially where alfalfa is grown, the injury is often much worse, 85 per cent being recorded in one instance.

As a preventive measure, the first crop of medium red clover should be clipped or cut early for hay to prevent the first generation of seed chalcids from depositing their eggs. Neighborhood co-operation in this should be urged. First year clover should be kept from blooming and volunteer clover destroyed.

BIBLIOGRAPHY

Bruchophagus funebris Howard

- 1899—Pettit, R. H.—Bull. No. 175, Mich. Agr. Exp. Sta., pp. 366, 367.
 1904—Titus, E. S. G.—Bull. No. 44, U. S. Dept. Agr., Div. Ent. pp. 77-80.
 1906—Webster, F. M.—Circ. No. 69, U. S. Dept. Agr., Bur. Ent., pp. 7-9.
 1909—Folsom, J. W.—Bull. No. 134, Ill. Agr. Exp. Sta., pp. 125-133.
 1911—Morrill, A. W.—Third Ann. Rep. Ariz. Hort. Comm., pp. 27, 28.
 1913—Swenk, M. H.—Bull. No. 1, State Ent. of Nebr., pp. 89-94.
 1914—Urbahns, T. D.—Farmers Bull. No. 636, U. S. Dept. Agr. pp. 1-10.

Habrocytus medicaginis Gahan

- 1915—Gahan, A. B.—Proc. U. S. Nat. Mus., Vol. 48 pp. 163, 164.
 1916—Urbahns, T. D.—Jour. Agr. Research, Vol. VII, No. 4, pp. 147-153.

Idiomacromerus longfellowi Girault

- 1917—Girault, A. A.—Descriptiones Hymenopterorum Chalcidoidicarum Variorum cum Observationibus III, p. 8 Hillmead Press, Glenn Dale, Maryland.

Tetrastichus bruchophagi Gahan

- 1913—Gahan, A. B.—Proc. U. S. Nat. Mus., Vol. 46, p. 439.
 1917—Urbahns, T. D.—Jour. Agr. Research Vol. VIII, No. 7, pp. 277-282.

A PRELIMINARY REPORT ON THE TROMBIDIIDAE OF MINNESOTA¹

BY C. W. HOWARD²

In the vicinity of Lake Minnetonka and other lakes near Minneapolis and St. Paul, summer visitors are attacked by "chiggers," similar to those found in the southern states, altho not so severe in their effects on man. They are apparently the larvae of a mite belonging to the *Trombidoidea*. Several forms in this group are also of economic importance in being enemies of insect pests. Three years ago a study of these mites was begun, part of the work centering about an investigation of the life history and biology of the members of the family *Trombidiidae*, found in Minnesota. The purpose was to make a complete study of this family before publication. As it will be impossible for the writer to complete this study, and as our information about the representatives of the family in America is very incomplete and fragmentary, the following descriptions and notes are presented at this time. Several apparently new species have been found in the state and these are also described.

Those wishing more general information on the superfamily are referred to Report 108, U. S. Dept of Agr., Office of the Secretary, by Nathan Banks, and to Redia, Vol. 8, No. 1, containing an account by Berlese of the trombidium mites of the world, but excluding North American forms almost entirely.

KEY TO ADULTS AND NYMPHS FOUND IN MINNESOTA

- A. Palpi with a single claw.
 - B. Dorsal groove expanded at the middle of its length.
 - C. A pulvillus between the tarsal claws; eyes truncate, a large species. *Allothrombium pulvinus*
 - CC. No pulvillus, eyes sharp pointed, a small species; a white band across abdomen. *Trombidium maculatum*
 - BB. Dorsal groove expanded at the anterior end. Abdomen deeply indented on the posterior margin. *Sericothrombium scabrum*
- AA. Palpi with two claws.
 - B. A chitinous plate on the posterior part of the dorsum. *Eutrombidium locustarum*

¹ Published with the approval of the Director as Paper No. 140 of the Journal series of the Minnesota Agricultural Experiment Station.

² In fairness to Mr. Howard, who has been in China since October, 1917, it should be stated that this paper has not been edited, corrected or revised by him.—A. G. R.

- BB. No chitinous plates on the abdomen.
- C. Tarsi I very much swollen, a very small species.
Microtrombidium magnitarse
- CC. Tarsi I not so large; larger species.
- D. White markings on the abdomen, eyes sessile, body hairs very slender. *Microtrombidium albovittatum*
- DD. No white markings on abdomen, body hairs not so slender.
- E. Body hairs spindle shaped, grooves on dorsum form an inverted triangle.
Microtrombidium triangulum
- EE. Body hairs stout, with expanded tips or globose; no constriction of abdomen.
- F. Hairs of body globose mixed with stout hairs whose expanded tips are turned backward.
Microtrombidium nopal-rubrum
- FF. Hairs stout and thick, or with expanded tips turned backward; six pairs of large pits on the dorsum.
Microtrombidium punctatum

KEY TO LARVAE

- A. Palpi with two claws, one simple and one bifurcate.
- B. Larger claw deeply bifurcate; spines on coxae slender and barbed; processes on mandibular sheath clavate with numerous spines on the tip. *Allothrombium pulvinus*
- BB. Larger claw not so deeply bifurcate, spines on coxae short and bifurcate; processes on mandibular sheath clavate.
Eutrombidium locustarum
- AA. Palpi with one bifurcate claw.
- B. Claws on third tarsi of equal length; processes on mandibular sheath blade-like or palmate.
- C. Anterior dorsal shield long and narrow, lateral edges curled under posterior dorsal shield quadrate in outline; processes on mandibular sheath blade-like.
Microtrombidium triangulum
- CC. Anterior dorsal shield as wide as long; lateral edges not curled under; posterior dorsal shield spindle-shaped; processes on mandibular sheath palmate.
Microtrombidium muscarum (?)
- BB. Claws on third tarsi not of equal length, the shorter one extends dorsad; processes on mandibular sheath brush-like.
Sericothrombium scabrum

Allothrombium pulvinus Ewing.

All. pulvinus Ewing (in manuscript)

Adult females: Color: dull scarlet, darker than *Eu. locustarum*, more nearly approaching Brazil red in tone, a small triangular area at

the base of the cephalothorax on the dorsum and posterior to the genital opening on the ventral side is usually brighter colored. Size: 3.75 to 5 mm long by 2 to 2.5 mm wide. The males are smaller. Body constricted near the middle, widest anteriorly, covered thickly with slender plumose hairs. On the dorsum of abdomen three transverse grooves and a median posterior depression; on the venter two transverse grooves; genital opening posterior to coxae IV, anal opening nearer to the posterior margin than to the genital opening. Cephalothorax wider than long, the base somewhat concealed by the overhanging abdomen. Dorsal groove expanded a little posterior of the middle. Eyes on long pedicels located a little further anterior than the expansion of the dorsal groove. Palpi with segment II nearly three times as long as segment I and considerably swollen, segment III about a third of segment II in length, IV twice as long as III, with a single stout claw at its tip. The thumb is as long as or longer than segment IV, a little clavate in outline. Mandibles long and slender.

The legs are long and slender. Between the claws at the tip of the tarsi is a hairy pulvillus. Tarsus of leg I not swollen. The male differs from the female in its smaller size, more pronounced dorsal and ventral grooves, and shorter and wider genital opening.

Nymph. Similar to the adults except in the following points: body smaller in proportion to the length of the legs, covering of hairs more sparse, cephalothorax and legs yellowish, while the body is dark orange colored, cephalothorax larger in proportion to the size of the body, and tarsi I slightly swollen. Size unengorged, 0.45 x 0.35 mm, engorged 0.80 x 0.60 mm.

Larva. Unengorged: color scarlet, size 0.30 mm long by 0.20 mm wide. Elliptical in outline, widest near the middle, ends broadly rounded. On the dorsal side an anterior chitinous plate or shield nearly a third of the length of the body and irregularly pentagonal in outline. Near the lower central portion a pair of very large pits from each of which arises a long slender barbed hair, three other pairs of stout barbed hairs near the margins. The paired eyes just laterad of posterior angles of this shield. A smaller elliptical plate just posterior to and contiguous to the anterior plate. Numerous heavy barbed spines on the abdomen. Ventral side with spines similar to the dorsum. Coxae very large, I and II contiguous, III separated slightly from II. Opening to tracheal system between I and II. The mouth parts are hidden beneath the dorsal shield. Palpi short and swollen, segment IV with a heavy bifurcate terminal claw and a smaller simple post-terminal claw. Thumb papilla-like with two very long

plumed hairs on the tip, besides several small hairs. Mandibles retracted into a surrounding sheath. On the base of this sheath is a pair of large clavate spines, brush-like at the extremity. Legs slender, tarsi all normal, with two stout curved claws and a dorsal tactile hair. When engorged the larva becomes 0.8 mm long by 0.5 mm wide. Coxae II and III become widely separated as well as the posterior dorsal plate from the anterior dorsal plate.

Eggs. Spherical 0.19 to 0.20 mm in diameter; outer shell smooth; color scarlet.

Adults collected at many points in Hennepin, Carver, Ramsey, and Washington counties, Minnesota, probably found in all parts of the state where conditions are suitable.

This species was named for me by Ewing as *Allothrombium pulvinus*, with the statement that his description was still in manuscript. It is extremely common in certain regions of Minnesota. What is probably the same species is mentioned by Riley and Johannsen (1914) as occurring about Ithaca, N. Y. It is the largest of our Minnesota species. The color is a dull scarlet, as if they had traveled over dry dusty soil and marred the original brightness of their velvety scarlet coats. On rocky or gravelly river banks where there is a great deal of undergrowth and where the soil is covered with fallen leaves they are especially common. They are seldom found close to the water's edge, but usually high up where the soil is dry. They are also found along the edges of woodlands where the growth is scrubby and even along the edges of cultivated fields. During the last spring, however, quite a few were taken in a low, wet, marshy flat along the banks of the Minnesota River in company with *Sericothrombium scabrum*, *Eutrombidium locustarum*, and *Microtrombidium magnitarse*. Because of its abundance fairly complete observations were made on this species.

Adults appear in late summer and autumn, i. e., from late August to late October. During this time they are active during mid-day hiding in the soil and leaves at night time until a heavy frost appears, after which they bury themselves in the soil in a cell two or more inches below the surface. There they spend the winter until the frost is out of the ground and small forms of animal life become active. By April 1 they once more become active and may be seen on the search for food or preening themselves in warm spots of sunshine. In doing this the legs and palpi are curled beneath the body, the mandibles and palpi are rubbed with the front tarsi, then the legs are brushed and cleaned with any tarsus which is convenient. In searching for food

the palpi and first pair of legs are held forward and act as feelers. As soon as a victim is touched it is grasped by the palpal claws and held as if in a hand between the claws and thumbs. The sword-like mandibles are thrust into the body, moved about by a more or less circular motion, and the body fluids sucked out. The mandibles may be removed several times and thrust in at a new location. From April 1 to the middle of June they continue their search for food. If sufficient food is at hand four to six days will suffice for full engorgement. The food consists of small insects and insect-like forms in the soil or on low plants. In the field we have seen them feeding on small coleoptera larvae, small adult chironomids which had fallen to the ground, small spiders and plant lice. In the laboratory they have fed on killed coleoptera larvae, injured centipedes, very small ant larvae, young grasshopper nymphs just emerging from the "amnion," aphids and their eggs, eggs of *Sericothrombium scabrum*, and upon members of their own species. It seemed to be more often the larger females which devoured the smaller males when there was a lack of natural food in the breeding jars. In the field the shrivelled remains of mites may often be found in such places as to arouse the suspicion that cannibalism may be fairly common. They seem to be extremely fond of plant lice and are often seen climbing plants and shrubs in search of them, going as high as two or three feet. This is the only one of our trombidiums which is commonly seen climbing plants. It is also able to walk up the sides of a glass jar. The presence of the pulvillus will explain this ability to climb. In the laboratory we have fed adults on the winter eggs of willow aphids and upon the aphids of box elder, salvia, aster, dahlia, sunflower, red clover, cherry, woolly aphid of the elm and upon white-fly larvae. They will also devour grasshopper eggs readily, but probably do not do so in nature, as they do not seem to show any tendency to burrow in their search for food. On the other hand while animal food seems to be their choice they will take other forms of food. On one occasion we found a specimen enjoying a meal from a crumb of moist bread which a picknicker had dropped on the ground. Repeatedly we have found them evidently sucking nectar from fallen oak catkins, and liquid from the sticky bud coverings of box elder, as well as sucking moisture from wet soil. One lot of several adults was brought into the laboratory and placed in a jar with very moist soil. No food was given. They were unengorged and several were noticed inserting the mandibles into clumps of moist soil exactly as if feeding on an insect. Next morning they were very noticeably increased in size. After a few days eggs were deposited.

This was repeated a second time and engorgement secured and eggs laid when soil moisture was the only food obtainable.

The periods of the life history are very irregular owing to the difficulty which some individuals meet in finding a sufficient food supply. As soon as the female has become engorged with food she prepares for oviposition. The larger number oviposit between April 22 and June 25. The mating process has not been observed except that in a breeding cage on one occasion in early April several pairs were engaged in what seemed a mild acrobatic contest. Altho the cage was watched closely no actual mating was seen.

The eggs may be placed at the surface under leaves or other detritus, or beneath the surface at a depth of three-eighths to one-half inch. The eggs are cemented together rather firmly and the mass further bound together by a few silvery silken threads. Each mass may contain from two hundred to four hundred eggs, depending upon the extent to which the female has been able to secure food before oviposition. The incubation period of the eggs is from three to five weeks, depending upon the temperature. At about the middle of the period of incubation the outer shell of the egg splits open and the legs of the embryo covered with the inner membrane protrude in a conical fashion above the ruptured edges of the egg shell. At this time the mass of eggs assumes a paler color. Hatching of the larvae occurs from late May to mid July.

Soon after hatching the six-legged larva crawls about upon the soil and up onto the vegetation, always going upward in search of some insect to which it may attach. Apparently plant lice are their favorite host. Several tried to engorge on adult *Arphia pseudonictana* and *Chortophaga viridifasciata*, but were unable to do so. They refused to feed on small beetle and ant larvae. The soft bodied aphid is more easily punctured by their small mandibles. They were reared on aphids from red clover, lettuce, box-elder, snowball and raspberry. As many as five or six may attach to one aphid, and in two to four days will swell to many times their original size. If disturbed or for any other reason dissatisfied they will detach themselves and roam about until they find another suitable aphid to which they will attach and feed. When, however, they are nearing engorgement removal from the host is difficult or impossible.

When fully engorged the larva drops to the soil and burrows one-eighth of an inch to two inches below the surface, depending on the character of the soil, and there it goes into a resting condition. This occurs usually during the month of June or early July. While in this

condition the larval skin hardens and the nymph is formed inside. About one week is spent in the soil after which the nymph appears at the surface. Nymphs are found from late June to late July. They resemble the adult closely except for size, and feed as do the adults on aphids and other insects. By late July they enter the soil once more or hide in curled up dried leaves at the surface. The skin hardens and inside is formed the adult mite. In about two weeks the adult bursts the old dried nymph skin and crawls to the surface of the soil. From this time, early to late August, onward, the adults feed until cold weather when they enter the soil once more and remain until early spring.

Altho somewhat localized in distribution this species must be very beneficial, especially in the control of aphids, as every stage feeds upon them, even destroying the winter eggs. It seems to have few enemies. Rove beetles in one of the breeding jars were seen to eat the adults and ants were seen attempting to carry them away. No other insect has been seen, however, to prey upon them in the field or in breeding jars, nor have any parasites been reared from them.

The larvae of this species seem to have no relation to the "chigger" pest. On several occasions large numbers were placed inside the writers stocking or underwear, but in no case did one attempt to penetrate the skin. Where they are most abundant there seems to be little trouble from "Chiggers."

Eutrombidium locustarum (Walsh).

Astoma locustarum Walsh, Practical Entomology, Vol. I p. 126;
1886 LeBaron, Ill. Report. 2, p. 61; 1875.

Astoma gryllaria Riley. 7th Missouri Report, p. 176; 1875.

Trombidium locustarum Riley, Rpt. U. S. Ent. Comm. p. 306;
1878.

Ottonia locustarum Banks, Trans. Am. Ent. Soc.: Vol. 21, p. 213;
1894.

Microtrombidium locustarum Ewing. System. and Biol. Study of
Acarina of Ill. Univ. Studies, Univ. Ill. Vol. 3, p. 94; 1909.

Adult female. Color, scarlet, darkening with age, in certain lights the folds on the abdomen have a whitish reflection, under side brighter than dorsal. Size, 2.75 to 3 mm. long by 2 mm. wide. When engorged may reach a length of 4 mm. long by 2.50 mm. wide. Body covered with slender plumose hairs; constricted near the middle, wider in anterior half, a deep transverse groove at the line of constriction, a second near the middle of the wide anterior half; a large trapezoidal chitinous plate at the posterior end of the dorsum, nearly a third as long as the abdomen, and a little longer than wide; a shallow arched

transverse groove anterior to the plate. On the ventral surface a deep transverse groove between the two anterior and the two posterior coxae and another just posterior to coxae IV, a longitudinal groove extending from this to the posterior end of the body. Genital opening opposite coxae IV. Anus less than half way between the genital opening and the posterior margin.

The cephalothorax inserted in a deep anterior emargination of the abdomen, wider than long, base somewhat hidden by the overhanging abdomen. Eyes sessile, two on each side, placed at about the middle of the length of the cephalothorax. Dorsal groove expanded at the middle of its length into a quadrate area bearing two stout spines. Palpi with segment II a little more than three times as long as segment I, segment III one-third as long as segment II, segment IV with two stout terminal claws, the smaller on the inner side. The inner surface of segment IV has a variable number of heavy spines, usually seven in a double oblique row; the oblique rows of spines are sometimes reduced to two in each row, and there may at times be few to several spines forming a dorsal crest on the segment, the number not always corresponding on the two palpi of a single specimen. The outer surface bears three very heavy nearly equal spines, near the ventral edge; in some specimens there may be only two, in others four; these may also vary on the two palpi of a single specimen; in ten specimens examined the number were as follows: 2-2, 4-4, 3-4, 3-2, 4-2, 3-3, 2-3, 2-2, 3-3, 4-3. Thumb longer than segment IV, of nearly equal diameter throughout length, four times as long as wide.

Legs slender; tarsi I nearly three times as long as wide.

Male. Similar to female except as follows: smaller, 2 to 2.50 mm long by 1 mm wide, constriction of body and grooves more marked, does not engorge so fully as the female, cephalothorax more exposed, dorsal plate only twice as long as wide, and more angular, abdomen narrower posteriorly, genital opening narrower, legs relatively longer than in female.

Nymph. Resembles the adult closely. Size 1.50 to 2 mm long by 0.75 to 1 mm wide. Hairs on dorsum sparse and of a paler scarlet, those on venter, legs, and cephalothorax cream colored. Body more pointed at posterior extremity. Cephalothorax resembles that of the adult, except that it is a little larger in proportion to the size of the body. Palpi has only two heavy spines present on the outer surface of segment IV while the inner surface has an oblique row of six heavy curved spines whose tips reach beyond the base of the terminal claw, and also a dorsal comb of five heavy hairs. The legs are slender,

longer in proportion to the size of the body than in the adult, tarsi I slender, two and one-half times as long as broad.

Larva, unengorged. Color, scarlet, size 0.20 mm long by 0.11 mm wide, oval in outline, wider in front. On the anterior end of the dorsal side is a large, more or less pentagonal chitinous shield, which completely hides the mouth parts beneath, and is more than a third as long as the body. Four pairs of spines are present on this shield, one of extreme length at each posterior angle. Posterior to it is a stout, wide, quadrilateral shield, also bearing four pairs of plumose hairs. Laterad of each posterior angle of the anterior shield is a pair of eyes. Abdomen with several plumose hairs—Ventral side, with the coxae large and contiguous. Opening of tracheal system between coxae I and II. Each coxa has a short stout bifid spine near the insertion of the legs. Mandibles sabre-like projecting from a tubular sheath beneath the dorsal shield, a pair of heavy clavate appendages on the ventral side of this sheath. Palpi short, segment IV with two claws, the terminal one larger and bifid. Thumb short and bears several stout hairs on its tip. Abdomen with stout plumose hairs. Legs stout, tarsi slender, claws long and slender, a tactile hair arising between the claws and extending dorsad of them. Tarsus III with one very long curved claw, the second claw short and thick and raised dorsally, ventrad below the long claw projects a stout heavily plumed pulvillus-like tactile hair.

Larva, engorged. Reaches a size of 1.22 to 1.30 mm long by 0.53 to 0.60 mm wide, losing all resemblance to its previous form. Body widely rounded at both ends, and somewhat constricted at the middle. Integument with fine transverse striations—Coxae I and II remain in contact, but tarsus III becomes separated with the expansion of the body as do also the two dorsal shields.

Eggs. Spherical, outer shell smooth and shining, color flame scarlet, 0.16 mm in diameter.

Adults taken at many points in Hennepin, Ramsey, and Otter-tail counties, Minnesota. It is apparently present throughout all the grasshopper areas of the state.

The adults of this mite are found on or in the soil in open ground during the early spring, the first warm days bringing them out of their winter hiding places. They start immediately in search of grasshopper egg pods. Riley records that in locust breeding grounds they may be so abundant as to give the soil a scarlet appearance. In grasshopper areas in Minnesota they may be so numerous in ordinary years that several hundred can be collected in three or four hours. During locust

cycles they become more noticeable. Apparently the character of the soil does not influence their distribution for they may be found on dry sandy hillsides and in low wet bottom lands, providing grasshopper eggs of one species or another are present. Every nook and crack in the soil is searched by the adults in their efforts to find grasshopper egg pods. When one is found they at once begin to dig down into it, doubtless aided materially by the heavy spines on the anterior edges of the palpi. Sometimes four or more may be found in one egg pod, but usually only one. The egg shells are pierced by the sharp blades of the mandibles and the contents sucked out until the shell collapses. How many eggs are necessary before the adult is fully engorged and ready for oviposition is not known exactly. Apparently three to four are sufficient. We have found this mite in the egg pods of *Melanoplus bivittatus*, *Melanoplus femur-rubrum*, *Melanoplus atlantis*, *Melanoplus minor*, and *Stenobothris curtispennis*. Probably the egg of any acridid will be eaten. It is possible that adults may subsist in part on moisture in soil. In cages we have secured partial engorgement and oviposition when the only food present was moisture in a soil rich with humus. While the female is entering the egg pod the males seem to be attracted to her, as many as three or four may be found attempting to enter the same burrow after the female. Actual mating of the sexes has not been observed. The female engorges to twice its previous size and becomes so swollen that the typical grooves on the body nearly disappear. The male does not engorge to such an extent. As soon as the female is full fed she excavates a smooth walled chamber not far from the egg pod where she fed and deposits her eggs after an interval of nine to twelve days. These chambers are half an inch to an inch below the surface of the soil. The eggs are bright orange color and very conspicuous against the dark soil. They can usually be found from late May to early June. Various masses of eggs in our breeding cages contained from three hundred to seven hundred eggs; their delicacy and the tenacity with which they are glued together makes accurate counting difficult. An average of four hundred to five hundred eggs is probably correct. In twenty-four to thirty days the eggs hatch. Previous to hatching, when the embryos are twelve to fourteen days old, the outer shell of the egg splits and the legs of the embryo project upward in a more or less conical manner thru the rent in the shell, still enclosed by the inner membrane. As soon as hatched the six-legged larvae crawl about rapidly in search of grasshoppers to which they may attach. Larvae which have just crawled upon grasshopper nymphs or adults may be found from late June to mid July, altho a few will be met with

even as late as early October. This unevenness in the life history is due to the delay which often occurs in the adult finding food in spring. The larvae attach themselves to any stage of the grasshopper from the first instar to the adult. They prefer to attach at a commissure between the segments of the abdomen or thorax, especially under or on the wing pads, or at the joints of the tarsi or about the mouth. On adults they often attach on the veins of the wings. The reasons for attaching at such points are obvious, when their delicate mouth parts are considered. Almost any species of acridid may be chosen as host. We have fed them on *Tettix* sp., *Melanoplus bivittatus*, *M. femur-rubrum*, *M. gladstoni*, *Stenobothris curtispennis*, *Orphulella speciosa* and *O. palidna*. Anywhere from one to one hundred twenty-four larvae have been counted on a single grasshopper nymph. The orange colored larvae soon engorge to several times their original size, losing all resemblance to their previous form and resembling engorged female ticks in appearance. In fact they are popularly known as grasshopper ticks. Engorgement may require as long as fourteen days. If it so happens that a larva has just attached to a nymph which is about to molt or is unable to penetrate the body wall and reach the body fluids and so not engorge readily, it will migrate to the moulted host after the skin is sloughed off, or to a more favorable part of the body. If, however, it has begun to engorge it is unable to migrate. Usually engorgement is completed between moults, or after the host has moulted to the adult stage.

As soon as the larva is fully engorged, which occurs for the majority by mid July, it drops off and enters the soil, burrowing from one quarter of an inch to one inch deep. The hardened larval skin acts as a cover for the developing nymph, which emerges in about five days. The nymph appears in late July to mid August when many grasshoppers are beginning to oviposit, and it at once searches for these eggs as food, altho at this time they may take other food than grasshopper eggs. We have had some partly engorge on angle worms and attempt to feed on larvae of *M. domestica*. The latter, however, proved too active. They will readily attack eggs removed from the oviducts of female grasshoppers. After engorgement, which requires fourteen to twenty days, they again enter the soil and pass through a transformation stage from which the adult emerges. The adult may eat at this time or it may go at once into hibernation. Most of those in our breeding cages refused to eat. The mature adults appear during late August when many grasshoppers are ovipositing.

The economic importance of *Eutrombidium locustarum* is un-

doubtedly great. The larvae, even if present in large numbers, probably do little more than weaken the grasshoppers to which they attach, but the adults and nymphs render a considerable service by destroying large numbers of grasshopper eggs. While they may not destroy all the eggs in any egg pod the fact that both nymphs in late summer and the adults in spring and to some extent in autumn feed on them, must make the aggregate destroyed quite large and we must consider them as one of the important natural checks on grasshopper increase.

The larvae of this species seem to have no connection with "Chiggers." They have twice been placed in large numbers inside the clothing of the writer but no unpleasant results followed. The fact that they inhabit open ground would clear them of any connection with the "Chiggers."

Microtrombidium magnitarse Ewing.

Micro. magnitarse Ewing. Ill. Univ. Studies Vol 3, p 92; 1909.

Adult female. Color, dull scarlet, size 1.50 mm long by 1 mm wide. Body oval, only very slightly constricted at the middle, widely rounded behind, wider in front, anterior edge concave, clothed thickly with short slender plumose hairs, the dorsal surface with a transverse groove just posterior to the forward margin, a second groove near the middle may be present or absent. Ventral surface with grooves corresponding to those on dorsum. Genital opening opposite coxae IV. Anus half way between genital opening and posterior margin.

Cephalothorax rather elongate, base concealed only in part by the abdomen. Dorsal groove expanded at the posterior end. Eyes sessile. Mandibles long and slender. Palpi stout but not much swollen, segment II nearly twice as long as wide, segment III as wide as long, segment IV twice as long as III, two long heavy claws at the tip, the inner one smaller. On the inner side, a crest of three or four heavy curved spines on the dorsal margin and three irregularly placed spines at the base of the thumb; thumb short and tapering, about three times as long as wide.

Legs slender, legs I not as long as the body; legs II and III three-quarters as long as I : legs IV reach beyond the end of the body. Tarsi I very much swollen, more than half as wide as long, usually held so that they are turned backward toward the body.

Male, smaller than female, 1 mm long by 0.50 mm wide, grooves more marked.

Adults of this species were collected in decaying leaves and wood

and other vegetable matter in low bottom lands along the Minnesota River near Minneapolis, also under decaying leaves in woodland about Lake Minnetonka and near the University Farm Campus in May 1917. Ewing records this species as collected from under the bark of an ash tree. In the laboratory we were unable to ascertain anything as to its habits except that it seems to prefer wet, decaying vegetable matter as its habitat. It is the smallest of our local trombidiums.

Microtrombidium triangulum, n.sp.

Adult female. Color, dark scarlet, lighter when engorged. Body elongate oval, broadest in front, narrower behind where it is broadly rounded, no marked median constriction. Size—1.55 mm long by 1 mm wide. Dorsal surface with a shallow transverse groove posterior to the cephalothorax, two other strongly marked transverse grooves, and at the posterior end three pits in the form of an inverted triangle, these and the tips of the grooves are connected by longitudinal grooves. On the ventral side a transverse groove posterior to cephalothorax and another below coxae I and II; genital opening opposite coxae IV; anus just posterior to genital opening. Surface of body covered with short, stout, spindle-shaped hairs, each covered with numerous branches. In the region of the cephalothorax and in the median portion of the venter these become long and more slender. The hairs on the legs are slender and branched.

Cephalothorax entirely exposed, wider than long. Eyes sessile. Dorsal groove with a prominent posterior expansion, Palpi short and stout, segment II swollen, two thirds as wide as long, segment III, as wide as long, a third as long as II, segment IV longer than III, two stout claws, the inner smaller thumb short and thick, pointed at tip, on the outer surface of segment IV a row of stout bristles forming a crest on the dorsal margin, seven other bristles arranged in diagonal rows on the outer face. The inner surface bears one heavy spine at the base of the thumb.

Legs slender, lighter colored than body, Tarsi I, short and swollen, a little less than half as wide as long.

Male. Similar to female—length 1 mm long by 0.70 mm wide.

Larva, unengorged. Of a light yellowish orange color. Body slender, length 0.25 mm by 0.13 mm wide. On the anterior end the chitinous shield is an elongate pentagon, not quite twice as long as wide, the two anterior edges are curled in toward the ventral side, a pair of small spines near the rounded anterior end and another near each posterior angle, in a large pit. Eyes are triangular plates laterad of the shield. Posterior shield quadrilateral, short and a little wider

than the anterior shield, bears two pairs of branched hairs. On the ventral side the mandibles are concealed inside of a slender tube with flaring mouth, on its ventral side a pair of serrate blade-shaped appendages. Mandibles scimitar shaped, with an expanded serrate blade at the tip. Palpi slender, segments of about equal length, thumb papilla-like with several long hairs on its tip, claw short, thick and nearly straight, slightly bifurcate at tip. Coxae very large, nearly touching on the median line, coxae I with two branched hairs, coxae II and III with one branched hair each. A pair of hairs opposite the interval between coxae I and II and coxae II and III. Spiracles between coxae I and II. Two pairs of branched hairs posterior to coxae III. Anus midway between coxae III and posterior margin. On the posterior end of the body are four long branched hairs.

Legs stout and long, tarsi normal except tarsi III, which resembles those of *Sericothrombium scabrum*.

Eggs. Typical as to shape and appearance, orange in color. Diameter 0.15 mm, fifty to one hundred in a mass.

Ten adults taken on June 16, 1917, in a small clearing on Big Island, Lake Minnetonka, Minnesota, near a low marshy area. Some were entering the soil to oviposit.

Attempts were made to rear this species from the eggs, but failed. The eggs require about twenty-five days to hatch, the shell rupturing and the legs of the embryo protruding after the eleventh day. The larvae are easily distinguished from those of the other species reared by their lighter yellowish color, and more elongate form. *Microtrombidium albovittatum*. n.sp.

Adult female. Color scarlet, under parts, legs and cephalothorax brighter. Size 1.65 to 2 mm long by 1 to 1.35 mm wide. Body slightly constricted in the middle similar to *Serico. scabrum*, but more slender and no posterior indentation, covered with slender plumose hairs. Two deep transverse grooves in the wide anterior part of the body, a third at the point of constriction, in the narrower posterior part three pits connected by two shallow grooves, and forming a V-shaped demarkation. Parallel to and just posterior to the anterior groove is a wide white band, on each lateral margin posterior to this band is a triangular white area with the base outward and apex extending between the second and third transverse grooves. On the ventral surface the genital opening is opposite coxae IV. The anus is half way between the genital opening and the posterior margin.

The cephalothorax is set in a deep anterior emargination, concealed partly by the overhanging abdomen, longer than wide. Eyes

sessile. Dorsal groove expanded at the posterior end. Palpi rather slender, segment II twice as long as wide at widest part, segment III as long as wide, one-third as long as II, segment IV as long as III, two claws at the tip, the inner smaller. Thumb almost cylindrical, slightly clavate, longer than segment IV. On the outer side of segment IV are three heavy spines at the base of the thumb, and near the base of the claw two long branched hairs projecting dorsally; on the inner side are two oblique rows of six or seven stout hairs each, legs slender, tarsi I not swollen, a little more than three times as long as wide, claws very long and slender, those of tarsi I much smaller than those on the other tarsi.

One specimen was taken in a cultivated garden in Minneapolis, along with *Serico. scabrum* on May 22, 1917, another at Fort Snelling in low lands, along with *Eu. locustarum* and *Serico. scabrum*.

This species might easily be confused with *Serico. scabrum* were it not for the white markings. Its habits also seem to be the same. In the laboratory it was impossible to find any food which it would take. On one specimen the white markings were more extensive than described above, the white triangles extended along the margin of the abdomen nearly to a transverse white band at the rear margin.

Microtrombidium nopal-rubrum, n.sp.

Adult female. Color, nopal red, lighter on the under side and legs. Size 1.50 mm long by 1 mm wide. Body flattened and oval in outline, wider in front, anterior edge deeply emarginate, posterior end rounded, no constriction at the middle. Entire dorsal surface sunken, with two deep anterior transverse grooves, two shallow median transverse grooves, present or absent, and a large, shallow, posterior, convex area. Ventral surface with genital pore opposite coxae IV. Anus just posterior to genital pore. Body covered thickly with peculiar stout branched hairs expanded at the top and turned backward. Mingled with these, especially near margins of the body are short globose hairs.

Cephalothorax as wide as long, set into a deep emargination of the abdomen so that it is entirely exposed. Clavate hairs on cephalothorax, with ends turned forward. Eyes sessile. Dorsal groove expanded on the posterior end. Palpi stout, and curved, segment II two thirds as wide as long, segment III as wide as long, segment IV a third longer than III, two stout terminal claws, the inner one smaller, thumb stout and cylindrical, as long as segment IV. Segment IV has on the inner surface a dorsal comb of stout hairs, also a double row of stout hairs parallel to the dorsal edge. On the outer surface are clavate hairs like those on the body. All other hairs are slender and barbed.

Legs rather stout, legs I as long as the body, legs IV reach beyond the body. Tarsi I three times as long as wide. Legs have clavate hairs on the dorsal side, slender branched hairs on the other surfaces.

Male. Smaller than female, 1 mm long by 0.5 mm wide, lighter colored, cephalothorax longer than wide, genital opening concealed with long bristles.

A female collected in leaf mold under trees along Minnehaha Creek, Minneapolis, May 2, 1917, also one male and one female collected in similar material on Big Island, Lake Minnetonka, Minnesota, June 16, 1917.

Microtrombidium punctatum n.sp.

Male. Color, pale orange red, size 1.50 mm long by 0.90 wide, body oval in outline, wider in front, not constricted at the middle, anterior margin concave, posterior margin widely rounded. Body and cephalothorax clothed sparsely with intermingled stout, blunt, barbed hairs, and knobbed hairs, with the knobs bent backward, the upper surface of the knob on these hairs is cuplike and filled with a soft membranous mass. Legs with knobbed hairs on the outer edges and slender barbed hairs on the inner edges. On the dorsum are six pairs of large, deep pits, but no grooves. On the venter the genital opening a little posterior to coxae IV, three times as long as wide. Anus the length of the genital opening posterior to it, very large and circular in outline.

Cephalothorax large, wider than long, not hidden by the abdomen. Eyes sessile, opposite the middle of the cephalothorax. Dorsal groove expanded at the posterior extremity. Palpi stout and strongly flexed, segment II not much swollen, a third longer than wide, segment III as wide as long, segment IV longer than III, two long slender claws on the tip, inner one smaller, thumb slightly clavate, longer than segment IV. On the inner surface of segment IV is a dorsal comb of stout spines, parallel to this is a row of six heavy spines in line with the base of the smaller claw, several stout spines are placed irregularly at the base of the thumb. On the outer surface of segment IV is a row of three heavy spines at the base of the thumb. Legs stout, legs I not quite as long as the body, legs IV reach beyond the body. Tarsi I somewhat swollen, three times as long as wide.

One specimen collected among fallen leaves in woodland, Minnehaha Creek, Minneapolis, May 16, 1917.

Microtrombidium muscarum (Riley) (?)

Atoma parasiticum Latreille. 1806 (larva).

Astoma parasiticum Riley, 7th Missouri Rpt. p. 177; 1875.

Trombidium parasiticum Murray—Econ. Ent. p. 129; 1877.

Trombidium muscarum Riley. 1st Rpt. U. S. Ent. Comm. p. 306; 1878. Banks. Trans. Am. Ent. Soc. Vol. 21, p. 213; 1894.

Microtrombidium muscarum Ewing. Ill. Univ. Studies, Vol. 3, p. 93; 1909.

The adult of this species has not been collected in Minnesota but must occur here, as what is probably the larva has been found three separate times, twice on adult *M. domestica*, (April 8, 1916, and July 8, 1914), and once in a manure pile (August 11, 1914). They were true trombidium larvae. The description follows:

Larva, partly engorged. Color scarlet, size 0.50 to 0.66 mm long by 0.35 to 0.45 mm wide. Oval in outline, widest a little before the middle, Dorsum with numerous branched hairs. On the anterior end a large pentagonal chitinous shield widely rounded on the anterior angle, three heavy spines near each of the lateral edges, two of these branched, the middle one unbranched and borne in a large pit; a pair of hairs near the anterior angle. Just laterad of this anterior shield, on either side, are the paired eyes on small elliptical plates. Just posterior is a narrow more or less spindle-shaped plate bearing a pair of branched hairs. Ventral surface with fewer hairs. Coxae I and II contiguous, with opening to tracheal system between. Coxae III separated from the others. Mouth parts completely hidden beneath the dorsal plate. Mandibles concealed inside of a cylindrical sheath which bears on its under surface two palmate appendages. Palpi short and stout, segments subequal, segment IV ends in a bifurcate sword-shaped claw, bearing a spine at its base. Thumb papilla-like, surmounted on the tip by several very long finely branched hairs. Legs slender, claws of tarsi normal, those of tarsus III like tarsi I and II.

Sericothrombium scabrum (Say)

Trombidium scabrum Say—Jl. Acad. Nat. Sci. Phila., Vol. 2, pt. I, p. 61; 1821.

Le Conte, Comp. Writings of Say. Vol. 2, p. 16; 1859.

Banks. Trans. Am. Ent. Soc., Vol. 21, p. 212; 1894.

Ewing. Ill. Univ. Studies, Vol. 3, No. 6, p. 90; 1909.

Adult female. Color, bright scarlet, pale on under side. Size, 2.25 mm to 5 mm long by 1.50 to 4 mm wide. Body strongly constricted in the middle, very wide in front, narrow behind, posterior edge rounded with a prominent indentation at the median point. The grooves on the dorsal surface form an angular figure 8. The ventral surface has anterior transverse groove, followed by a second and a

third arched groove which may join the second in the middle and pass laterally below the hind coxae. The cephalothorax is set into a deep anterior emarginatum on the ventral side and with it the first two pairs of coxae; when at rest or disturbed the anterior legs and palpi are curled into this emarginatum so as to be invisible from above. Coxae III and IV are near the point of constriction. The genital opening is opposite coxae IV. The anus is just posterior to the genital opening. Body thickly covered with stout, blunt, barbed hairs, giving it a velvety appearance. The hairs on the legs and palpi are slender and taper at the tip.

The cephalothorax is almost completely hidden by the projecting abdomen. Dorsal groove with the expansion at the anterior end. Eyes on rather long pedicels and placed rather far forward, a little posterior to the level of the expansion of the dorsal groove. Palpi stout, and somewhat swollen, segment IV as long as III, thumb as long as segments III and IV, swollen distally, one strong claw on the tip of segment IV, fine branched hairs on all the segments. Legs of moderate length, tarsus I somewhat swollen, three times as long as wide.

Male. Smaller than female, 1.25 to 1.50 mm long by 1 mm wide, abdomen more strongly constricted at the middle, and grooves more strongly marked. Genital opening longer and narrower.

Nymph. Not reared.

Larva, unengorged. Color, scarlet; size 0.16 mm by 0.31 mm. Dorsum with an anterior pentagonal chitinous shield. Three branched spines at the lateral angle of this shield close together. Posterior dorsal shield quadrilateral in outline and close to the anterior shield. Ventral side, with mouth parts hidden from above by the dorsal shield. Palpi short, and swollen, only one terminal claw, which is scimeter shaped and bifurcate; papilla-like thumb bears several long hairs. The thick, sharp mandibles have a heavy tooth at the base. On the ventral side of the mandibular sheath is a pair of short, stout processes divided brush-like into numerous long, fine branches. Coxae I and II contiguous, each with two long branched hairs; elongate opening to tracheal system between them. Coxae III separated from the others and with only one branched hair. Legs slender, tarsi I and II normal, tarsi III as in *Eu. locustarum* larva. Anus near posterior margin, four heavy spines on the posterior margin, each nearly a third as long as the body.

Eggs. Spherical in outline. Shell smooth and shiny. Color chrome yellow. Size 0.15 mm to 0.17 mm in diameter. About 300 to 400 placed in a cluster as in other species.

This species has been collected in Hennepin, Ramsey, Otter Tail, Roseau and Nicollet counties, and is probably distributed over the entire state. This is undoubtedly the species which Banks calls *Trombidium seucium*. It is the commonest and most evenly distributed trombidium found in Minnesota, altho not so abundant in any given locality. The minute, short, chunky, bright scarlet adult can be found almost any day from early spring to midsummer, running about the soil of cultivated fields. They move with a nervous energy looking into every crack and crevice in search of food. Not only are they common in cultivated land, but also in woodland, among the fallen leaves, on dry hillsides and in wet bottom lands. Sometimes one can collect this species, *Allothrombium pulvinus*, *Eu. locustarum* and *Micro. magnitarse* in the same place. Occasionally one may be found climbing the bark of a tree.

We have never yet seen one feeding in the open. On one occasion they refused grasshopper eggs.

Oviposition has occurred in breeding jars on several occasions. One lot of eggs was laid on July 1. These hatched about July 15, a nymph was found in the soil on August 13 but died before the adult emerged. A second lot of eggs was laid on June 13, these hatched on July 22. A third lot of eggs laid on May 22, hatched about July 1. The rupturing of the egg shell occurred seven to ten days after the eggs were laid. In a fourth attempt to rear this species, adults were fed on small insects collected by sweeping grass and shrubbery. Engorgement was secured easily, but it was not possible to find what insects were chosen for food. When fully engorged they become very rotund and the stretched skin shiny. Egg masses were placed on June 20 to 22 under leaves at the surface of the soil or in the soil even to the depth of an inch. Each mass contained about 200 eggs of a lemon yellow color, becoming more orange colored with the development of the embryo. After about seven to ten days the shells began to rupture. About twenty-two days were required before hatching took place.

It was found that these larvae would readily attack a white rat, but not a young pigeon or a thirteen-lined gopher. On the rat they burrowed into the skin and caused lesions similar to those caused by chiggers on man.

The eggs are easily distinguished from those of the other common species by their larger size and lemon yellow color.

Trombidium maculatum. n.sp.

Adult female. Color dark scarlet, an irregular transverse white

band just anterior to the groove opposite median constriction of the abdomen, the spines in this area white. Very much wider in front than behind, size 2.5 mm by 1.5 mm. Abdomen overhangs the cephalothorax slightly, clothed with stout, thickset tapering hairs, each with numerous long branches. A shallow groove near the anterior margin, a second deep one at the median constriction, a third arched groove posterior to this, with three pits forming a triangle near the posterior end. Ventral surface of a creamy color except that portion posterior to the last coxae. Cephalothorax set into an anterior emargination together with coxae I and II. Coxae III and IV near the median constriction, genital opening opposite coxae IV, anus two-thirds of distance from genital opening to margin of body.

Legs slender, tend to a creamy color except legs I which are scarlet, legs II shortest, legs IV reach much beyond body. Tarsi I about five times as long as wide. Covering hairs of legs slender.

Cephalothorax light colored—wider than long—Dorsal groove with the expansion in the middle. Eyes stalked, about opposite the expansion of the dorsal groove, sharp pointed at the top. Palpi short and thick, segment II very much swollen, nearly as wide as long; segment III wider than long, about a third as long as II; segment IV twice as long as III, a very heavy tooth on the extremity, longer than the segment; thumb slender, clavate and reaching beyond the end of the claw; long, slender, branched hairs on segment IV reaching nearly to tip of claw.

Male. Similar to female—size 1.4 by 0.95 mm. Legs more slender, and grooves of body more marked. Outline of body is more wedge-shaped.

Two males and a female taken in leaf covered humus under wild raspberries, Big Island, Lake Minnetonka, Minnesota, June 16, 1917.

“CHIGGERS”

Under this heading will be described the undetermined larva which attacks man in Minnesota. It is obviously the larva of one of the Trombidiidae and according to Oudemans (1912) would be the larva of a *Microtrombidium*. It does not, however, conform to the characters of one member of this genus, which we have bred and which is described in this paper. These larvae will attack birds as well as man. During the summer of 1916, large numbers of prairie chickens, quail and pheasants were attacked by them on the Game Preserve at Lake Minnetonka. They penetrated the skin so thickly about the neck, anus and under the wings that immense areas of the skin were in-

flamed, and many birds were so weakened as to become victims of dysentery and died. The mites did not bury themselves in the skin, but inserted the mouth parts and filled with blood. Some were seen fully engorged and walking away or dropping to the soil. When attacking men they do not seem to bury themselves in the skin, and the results of their bites are not so severe or extensive as usually described, but are similar to those of poisonous insects. The small area of inflammation lasts for only a few days unless scratched or otherwise irritated and then disappears. Individuals, however, differ in their susceptibility to these mites.

Description of larva: Nearly circular in outline, color scarlet; size 0.25 by 0.17 mm. Dorsal surface with numerous long, stout barbed hairs; a trapezoidal shield at the anterior end, about twice as wide as long, and bearing four pairs of barbed hairs; paired eyes just laterad of the shield. The heavy capitulum is well exposed from above, widely petagonal in outline with the point forward, the mandibles protruding beyond it; a wide, shallow median groove extending its entire length. Ventral side with numerous barbed hairs, coxae close together, stigmata between coxae I and II, anus about half way between coxae III and posterior margin of body. Mandibles enclosed in a more or less cylindrical sheath. Palpi stout and curved toward median line, borne at the lateral angle of the capitulum on the under side; segments II and III about as wide as long, segment IV nearly twice as wide as long, claw on segment IV long, stout and bifurcate, thumb stout and having several long plumose hairs on its tip.

Legs stout with numerous barbed hairs.

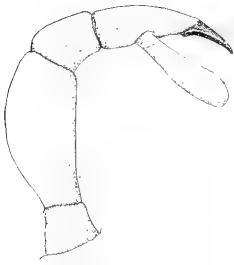
BIBLIOGRAPHY

- Banks, N. Some New American Acarina. Trans. Am. Ent. Soc. 21, pp. 209-229; 1894.
- Banks, N. The Arcarina or Mites. Rept. No. 108, U. S. Dept. Agri., Office of Secy. 1915.
- Berlese, A. Trombidiidae—Redia—8, p. 291; 1912.
- Chittenden, F. H. Harvest Mites or Chiggers—U. S. Farmers' Bul. No. 671; 1915.
- Ewing, H. E. Syst. and Biol. Study of the Acarina of Ill. Bul. Univ. of Ill., 7, p. 120; 1909.
- Murray, A. Economic Entomology, Aptera, London, 1897.
- Osborn, H. and Underwood, L. M. Prelim. list of species of Acarina of N. Am.—Can. Ent., 18, pp. 4-12; 1886.
- Oudemans, A. C. Die bis jetzt bekannten larven von Thrombidiidae und Erythraeidae—Zool. Jahrbücher, Suppl. 14, pp. 1-230; 1912.
- Riley and Johannsen. Handbook of Medical Entomology, p. 60; 1915.
- Riley, C. V. Report U. S. Ent. Com.; 1878.

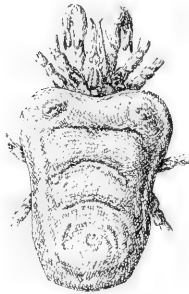
PLATE V

Allothrombium pulvius

- A—Dorsal view of adult female. x12
- B—Ventral view of adult female. x12
- C—Palpus of adult. x50
- D—Fourth segment of palpus. x75
- E—Mandible. x50
- F—Blade of mandible. x260
- G—Tip of tarsus I showing pulvillus. x75
- H—Eyes. x75
- I—Coxae III and IV of adult. x25
- J—Hair from body of adult.
- K—Dorsal surface of larva. x80
- L—Ventral surface of larva. x80
- M—Process on mandibular sheath. x490
- N—Palpus of larva. x330



C



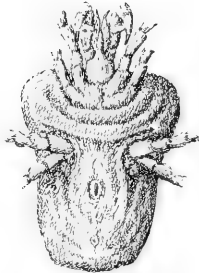
A



E.



D.



B



F.



G.



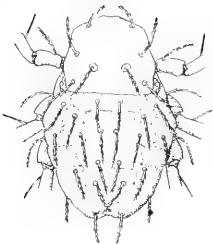
H.



I.



J.



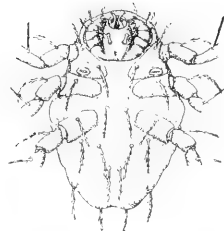
K



M



N



L.

PLATE VI

Eutrombidium locustarum.

- A—Dorsal surface of female. x8
- B—Ventral surface of female. x8
- C—Palpus. x25
- D—Segment IV of palpus. x50
- E—Tarsus I of adult. x25
- F—Eyes. 55
- G—Hair from body of adult. x55
- H—Posterior dorsal plate of male. x12
- I—Posterior dorsal plate of female. x12
- J—Dorsal surface of larva. x150
- K—Ventral surface of larva. x150
- L—Mouth parts of larva. x300
- M—Segment IV of larval palpus. x600
- N—Tarsus III of larva. x300
- O—Engorged larva—dorsal surface. x25

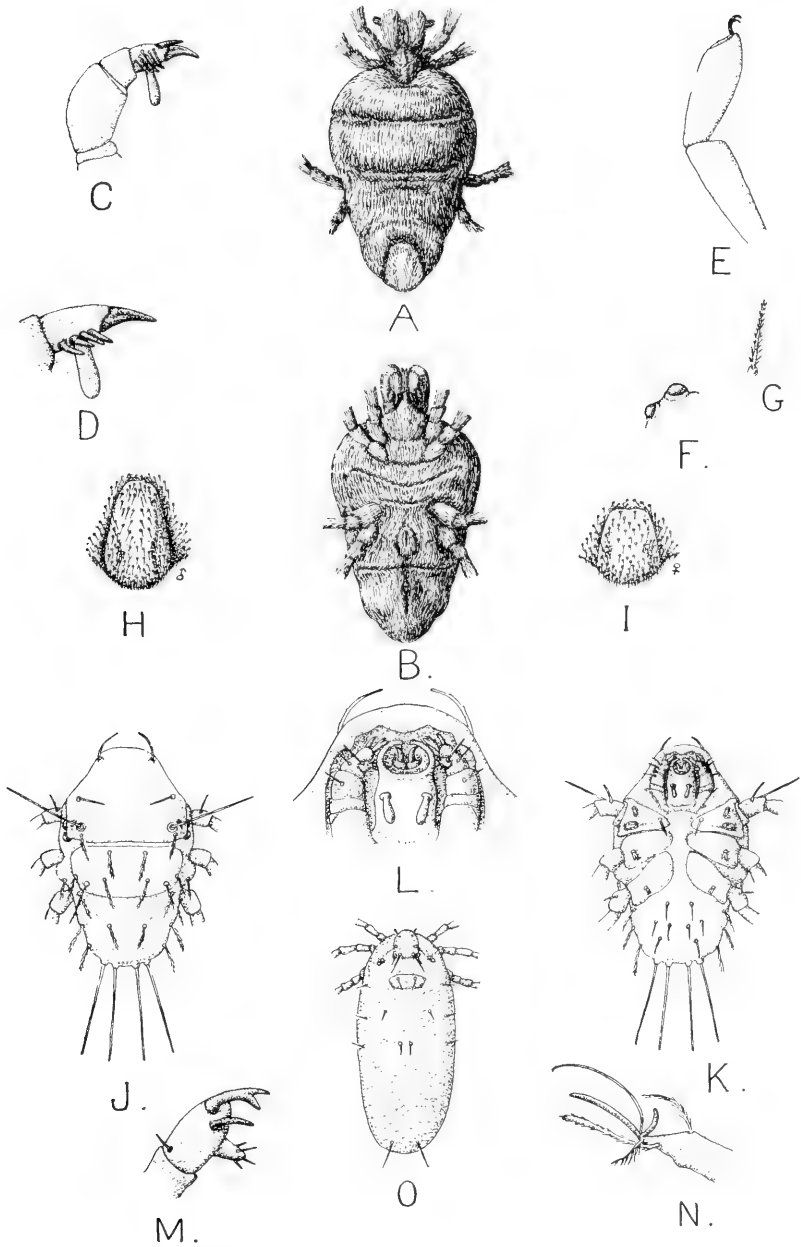


PLATE VI

PLATE VII

Scricotrombium scabrum.

- A—Dorsal surface of female. x15
- B—Ventral surface of female. x15
- C—Palpus of adult. x30
- D—Leg I of adult. x30
- E—Eyes. x50
- F—Hair from body of adult. x350
- G—Dorsal surface of larva. x100
- H—Ventral surface of larva. x100
- I—Segment IV of larval palpus. x400
- J—Tarsus III of larva. x400
- K—Tip of mandible of larva. x400
- L—Process of mandibular sheath. x600

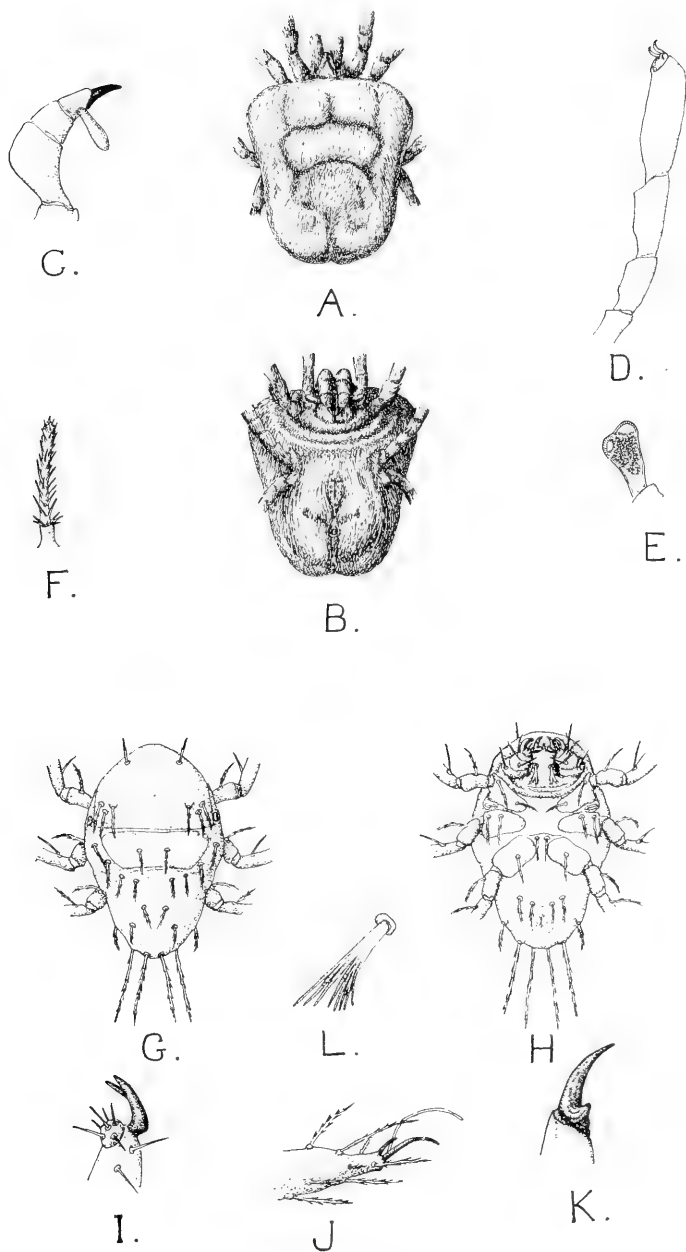


PLATE VII

PLATE VIII

Microtrombidium triangulum.

- A₁—Dorsal surface of female. x16.
E₁—Palpus of adult. x65
C₁—Segment IV of palpus, inner surface. x65
D₁—Tarsus I of adult. x35
E₁—Hair of body. x600
F₁—Hair from legs and palpus. x600
G₁—Dorsal surface of larva. x90
H₁—Ventral surface of larva. x90
I₁—Process from mandibular sheath of larva. x720.
J₁—Mandible of larva. x630
K₁—Segment IV of palpus of larva. x360

Trombidium maculatum.

- A₂—Dorsal surface of female. x25
E₂—Palpus. x100
C₂—Tarsus I. x50
D₂—Eye. x350
E₂—Hair from body. x450.
F₂—Hair from body. x450

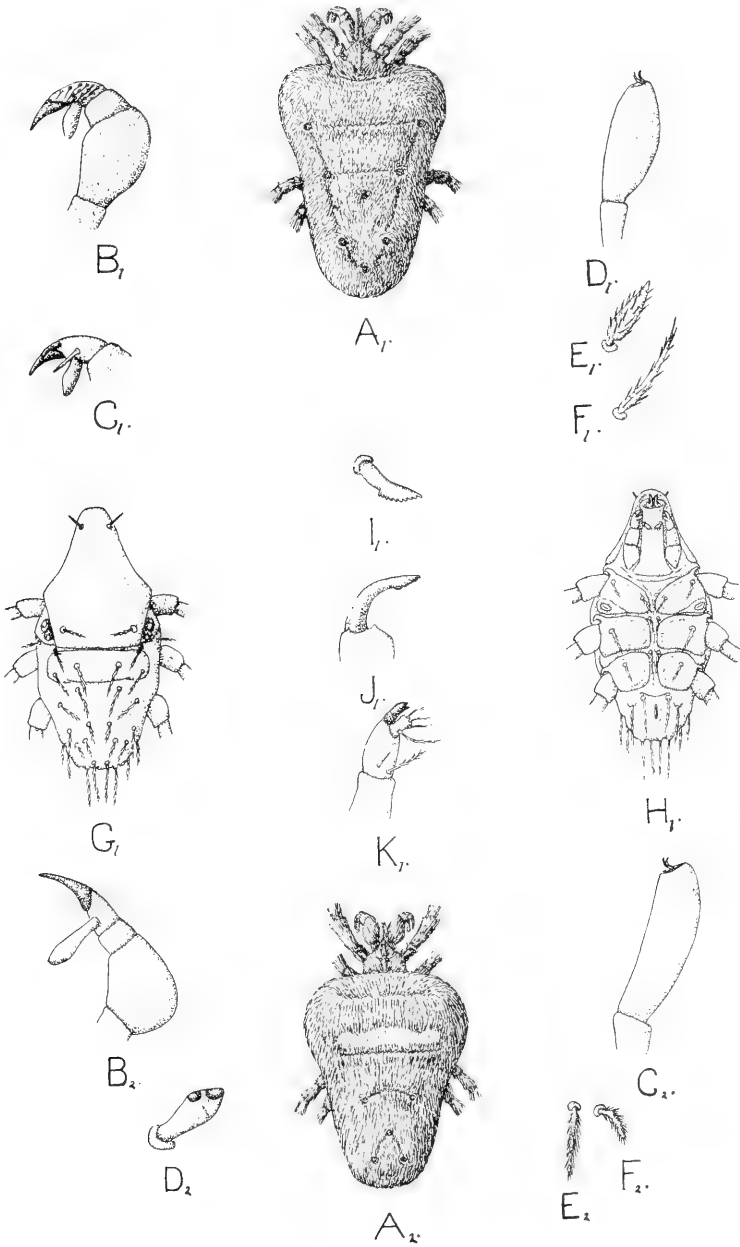


PLATE VIII

PLATE IX

Microtrombidium nopal-rubrum.

- A₁—Dorsal surface of female. x15
 B₁—Palpus, inner surface. x60
 C₁—Tarsus I. x30
 D₁—Hair from legs. x120
 E₁—Hair from body. x120
 F₁—Hair from body. x120
 G₁—Hair from body. x120
 H₁—Hair from body. x120
 I₁—Hair from body. x120

Microtrombidium magnitarse.

- A₂—Dorsal surface of female. x20
 B₂—Palpus, inner surface. x30
 C₂—Tarsus I. x40
 D₂—Hair from body.

Microtrombidium punctatum.

- A₃—Dorsal surface of male. x15
 B₃—Palpus, outer surface. x45
 C₃—Segment IV of palpus, inner surface. x45
 D₃—Tarsus I. x30
 E₃—Hair from body. x150
 F₃—Hair from legs and palpus. x150
 G₃—J₃—Hairs from body. x150
 K₃—Eye. x75

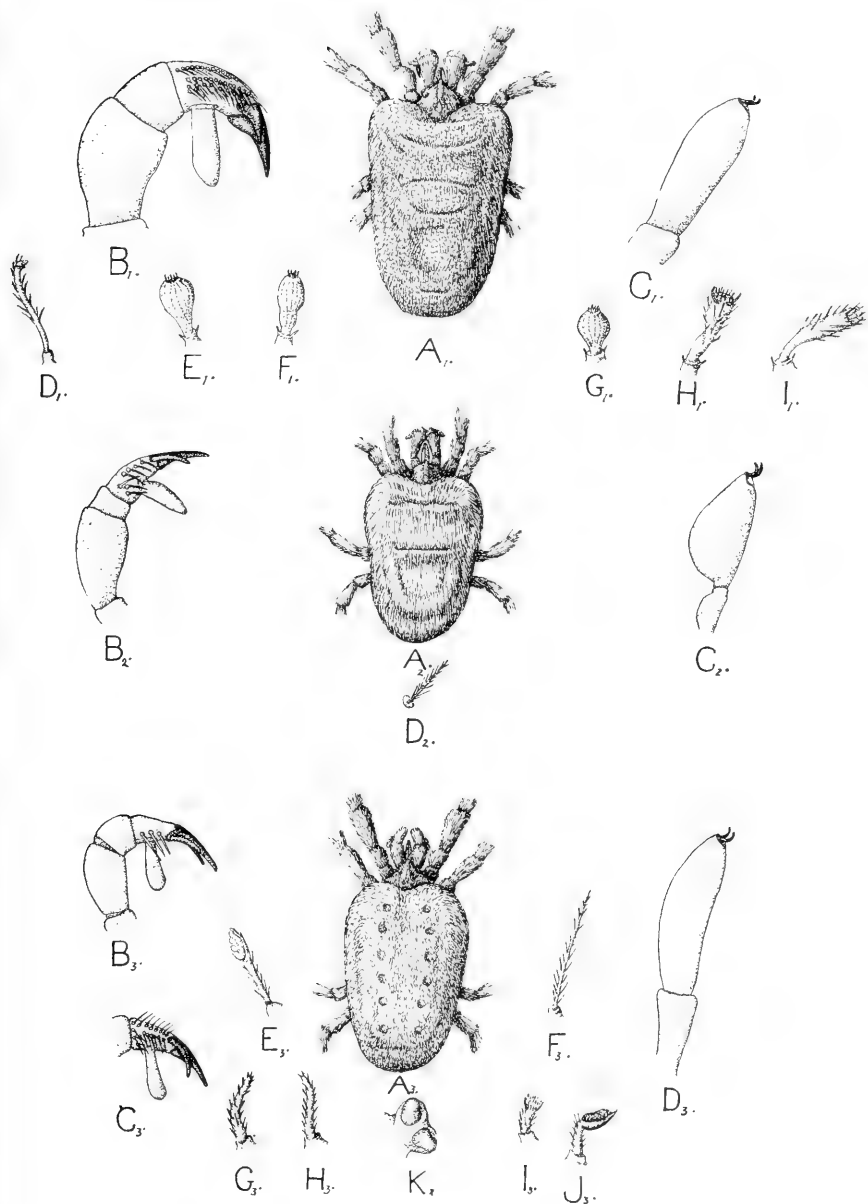


PLATE IX

PLATE X

Microtrombidium albovittatum.

- A₁—Dorsal surface of female. x20
- B₁—Palpus, inner surface. x60
- C₁—Segment IV of palpus, outer surface. x60
- D₁—Tarsus I. x80.
- E₁—Eye.

Microtrombidium muscarum. (?)

- A₂—Dorsal surface of partly engorged larva. x66
- B₂—Ventral surface of partly engorged larva. x66
- C₂—Mouth parts of larva. x333
- D₂—Segment IV of larval palpus. x666
- E₂—Process from mandibular sheath. x1000
- F₂—Tarsus III of larva. x200

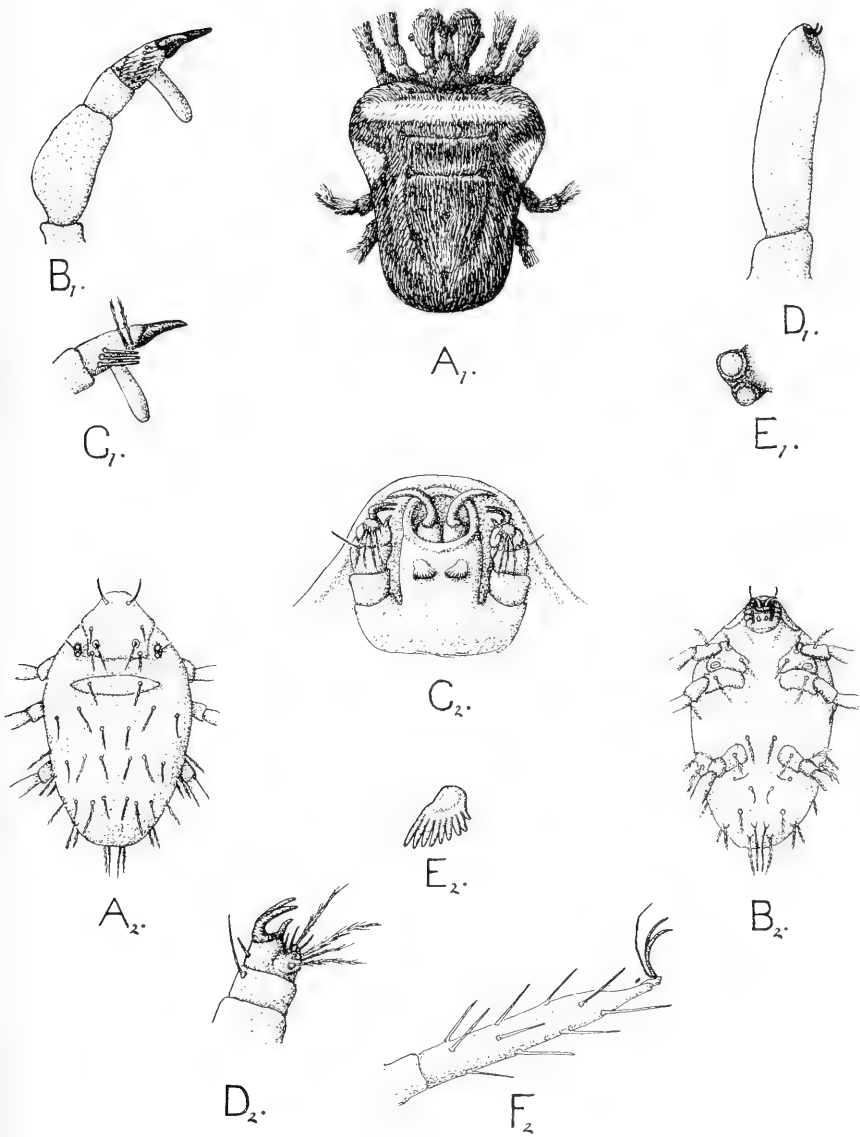
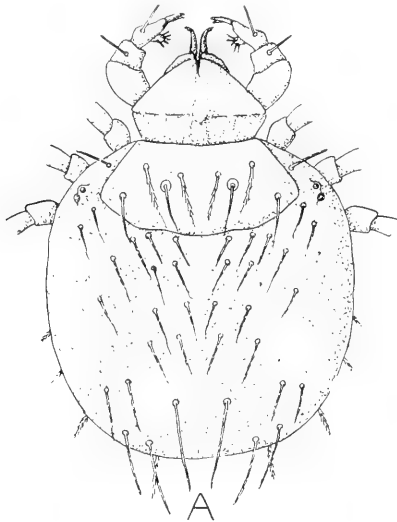
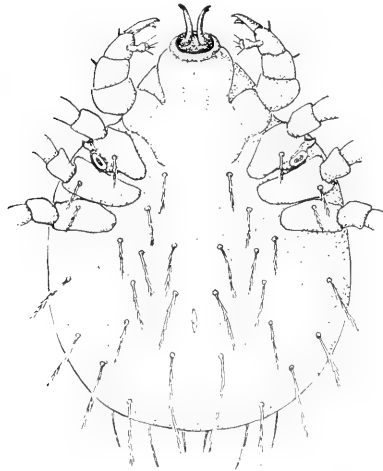


PLATE X



A



B.



C.

PLATE XI
"Chigger Mite."

A—Dorsal view. x160
B—Ventral view. x160
C—Palpus. x240

THE HYMENOPTERA OF MINNESOTA*

BY F. L. WASHBURN

The Minnesota Entomologist's reports issued between the years 1895 and 1901 comprise, amongst other subjects, treatises on certain orders of insects as they occur in Minnesota. Dr. Lugger, State Entomologist during that period, issued one report on the Grasshoppers of Minnesota, another on Butterflies and Moths, another on the Beetles, and still another, the sixth and last, on the Bugs of the state. It was evidently his intention, had he not been prevented by death, to complete the series, issuing reports on Diptera, Hymenoptera and possibly other groups of minor importance.

The writer published in 1905 a brief report on the Diptera, listing perhaps not more than one-tenth of the species of two-winged flies occurring in the state. Subsequently, a list of additional species was issued. For several years, at times when other work permitted, he has been working upon the Hymenoptera. The results of this work are embodied in this publication.

In view of the fact that hitherto no special effort has been directed towards the study of this group in Minnesota, and hence comparatively little collecting has been done, it is gratifying to note that our collection at this time includes as many species of wild bees as have been taken in that favorite collecting ground of entomologists, namely—the state of New Jersey.

Readers of this report should realize that securing anything approaching *all* the species occurring in Minnesota would mean many years of collecting; hence no list of Minnesota species would be approximately complete, which did not represent the work of a lifetime in collecting in this state. We list all species collected and determined to date, emphasizing in descriptive text those of economic importance.

In presenting this report on Hymenoptera, we take pleasure in acknowledging the invaluable assistance of Mr. H. L. Viereck of the United States Biological Survey, in identification of species, and in various other lines connected with the technical part of the work. The colored plates and drawings, except where noted, were made by Miss I. L. Wood under the author's direction. We acknowledge the courtesy of the officers of the State Geological and Natural History Survey of Connecticut in allowing us to use the drawings referred to

*Published with the approval of the Director as Paper No. 156, of the Journal Series of the Minnesota Agricultural Experiment Station.

below. Mr. Warren Williamson, of this department, was of material assistance in compiling material in the early part of the work.

We wish to acknowledge also material assistance in identification of specimens afforded by S. A. Rohwer and associates, Dr. W. M. Wheeler, Dr. J. Chester Bradley, Dr. H. T. Fernald, and Dr. M. T. Swenk. Dr. H. J. Franklin identified most of the *Bombids* and species in a few other groups. Dr. Headlee, of the New Jersey Station, kindly loaned certain cuts previously used in a New Jersey report, Howard's Insect Book and in Insect Life. C. W. Hooker identified our *Ophioniini*.

To serve students of Hymenoptera, a brief technical description of each family is inserted and in explanation of same, descriptive figures used in "The Hymenoptera or Wasp-like Insects of Connecticut"* are printed herewith.

We have not hesitated to use technical matter from the Connecticut volume wherever it was thought that it would be helpful, believing it to be the best work on the subject up to the date of its publication. Subsequent to that time, a certain amount of hymenopterous literature has appeared, which has thrown additional light on classification and caused us to depart somewhat from the plan followed in the Connecticut volume. The changes referred to will be apparent to the student.

It is believed that with the brief technical synopsis, introducing each family and the figures above alluded to for reference, there is no pressing need of a synoptical key or a glossary.

THE MINNESOTA COLLECTION

Experts in Hymenoptera pronounce our collection one of the best in the country outside of some of the larger eastern collections, and that of the Federal Bureau. Dr. Lugger, however, habitually neglected to place locality labels with his specimens. While he probably knew personally exactly where each specimen was collected, he did not appear to be impressed with the necessity of leaving a record for those who came after him. The result is that we have very many species in the collection, without doubt to be credited to Minnesota, which nevertheless we hesitate to include in our faunal list. Many of the boxes in the Lugger collection are filled with specimens undoubtedly taken here,

*State of Connecticut State Geographical and Natural History Survey Bulletin No. 22, Guide to the Insects of Connecticut, prepared under direction of W. E. Britton, State Entomologist, by H. L. Viereck with the collaboration of A. D. MacGillivray, C. T. Brues, W. M. Wheeler and S. A. Rohwer.

though lacking the locality label. We have, in this publication, credited to our state fauna only those individuals labelled as collected here, or which have been reported on indisputable authority as occurring within the state. Manifestly many times more species occur in this state than are indicated in this publication.

An excellent account of egg laying of gall flies may be found in Volume 3, Proceedings of the Entomological Society of Washington and in Kellogg's "American Insects." Howard's "Insect Book," pp. 26-28 has an interesting description of the *Vespidae*, while the valuable observations of the Peckhams may be found in the Wisconsin Geological and Natural History Survey Bulletin No. 2, Scientific Series No. 1. In this work under the headings, "The Little Fly Catchers," "The Toilers of the Night," "Enemies of the Orthoptera," "The Bug Hunters," "Some Grave Diggers," and other more technical titles, they discuss the *Oxybelidae*, the *Crabronidae*, the *Trypoxylonidae*, the *Sphecidae*, the *Astatidae*, *Cerceridae* and other families. The student is referred to Page 12 of Howard's Insect Book and to Volume VI of the Cambridge Natural History for the habits of *Andrena*. Howard's Insect Book also contains a good account of the leaf-cutting bee, the life history of bumble bees and the habits of the small carpenter bee, as well as furnishing the student with a large series of photographs of pinned Hymenoptera. The student of the order cannot afford to miss the valuable material found in Fabre's "The Bramble Bees and Others," "The Mason Bees," and "The Hunting Wasps." An abundance of other matter of a popular nature pertaining to Hymenoptera is available to students, and technical synopses of the group and descriptions of genera and species occur in our leading entomological journals.

CHARACTERISTICS OF HYMENOPTERA

This order is characterized by the presence of four wings, membranous, and for the most part, translucent, and with but few cells. The hind wing of each side, is, in flight, more or less firmly fastened to the front wing by a series of hooks on the front edge of the former, which articulates with a fold on the rear edge of the front wing. The mouth parts of the adults are adapted for biting and sucking. The ovipositor of the female is usually modified to form a sting, piercer or saw.

Hymenopterous insects have a complete metamorphosis, i.e., distinct egg, larval, pupal and adult stages. The larva, frequently re-

ferred to as "grub" or "maggot" is generally, but not always (notably sawfly larva), footless. The pupal stage is quiescent and exhibits all the appendages of the adult enclosed in a pupal sheath. This pupa may or may not be contained in a cocoon. In the bees and wasps the pupal stage is passed in the comb. Of all the orders of insects, the Hymenoptera contains perhaps the most species and amongst them some forms which have a most important bearing upon man's welfare.

A student of Hymenoptera is impressed with the fact that apart from the highly useful activities of the honey bee, the two most important and useful functions exhibited by the group are those of pollination or cross-fertilization so necessary in the production of good seed and good fruit, and of parasitism, by which characteristic the number of injurious insects is materially reduced.

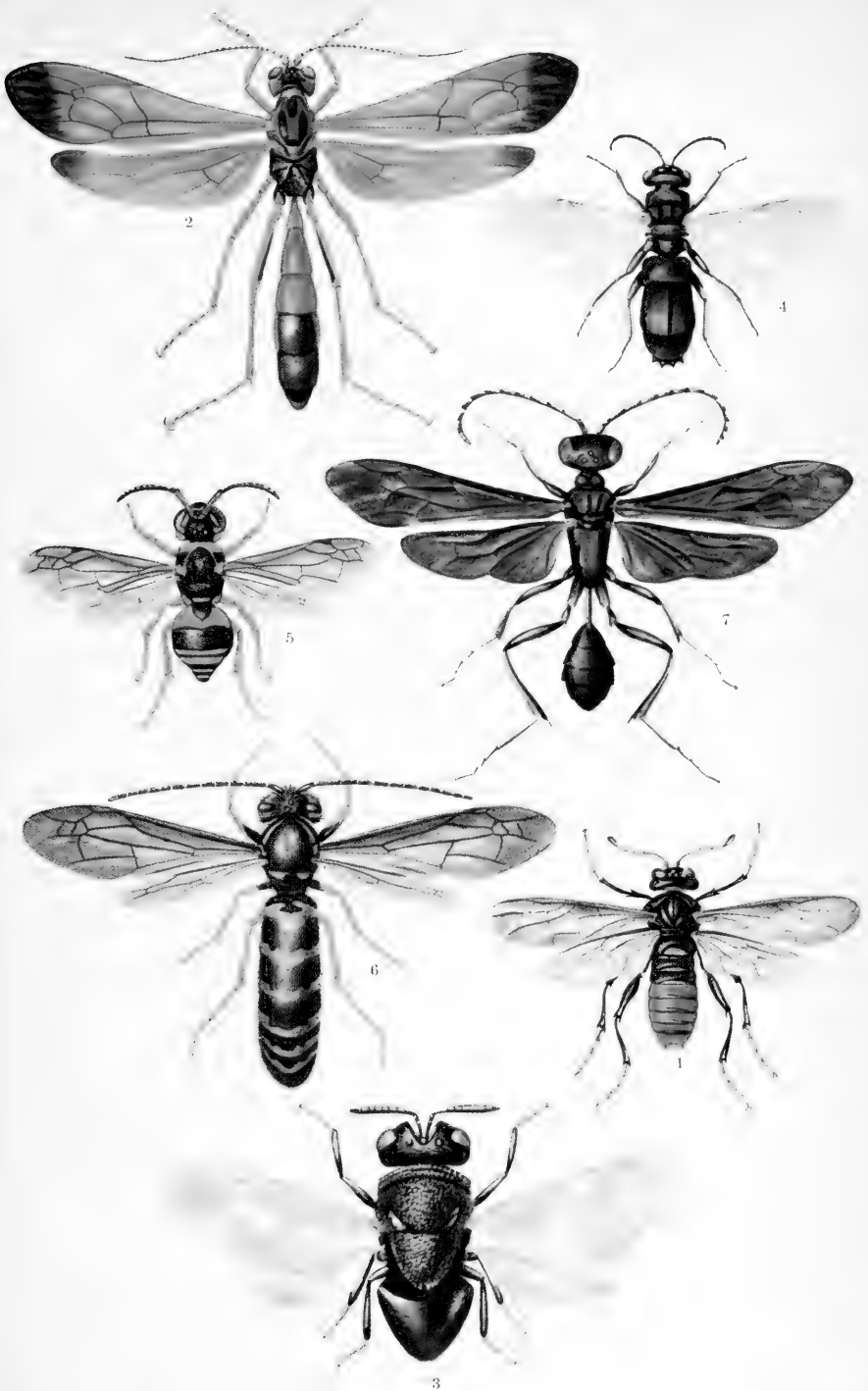
The modifications of flowers to bring about cross-fertilization by insects, and to prevent self-fertilization, are many and striking. In an observation covering twenty-six days, 275 species of insects were observed to visit the flowers of *Pasturaca sativa*; of these, 173 species belonged to Hymenoptera. Of 115 species of insects visiting milkweed, 52 were Hymenoptera and 42 Diptera. Of 87 species observed on the flowers of willow during 7 days, 43 were Hymenoptera. It will be noted that this group is an important one in this connection.

The services of Hymenoptera in the matter of parasitism have been referred to above. Suffice it to say that the Hessian fly, Tussock moth, scale insects, plant lice and a host of others are kept within bounds by the activity of hymenopterous parasites. These are chiefly occupied in destroying the tribes of vegetarian insects; 63 species attack a certain species of moth; the American Tent Caterpillar is said to be parasitized by 12 species of Hymenoptera, to say nothing of attacks upon them by Dipterous parasites. From a single caterpillar of the Cabbage Moth (*Plusia brassicae*) over 3,000 individuals of *Copidosoma truncatellum* have been bred by Girard.

On the other hand, we find in this group, many injurious forms such as the larch sawfly and other sawflies and many gall makers.

EXPLANATION OF COLORED PLATE 1

1. *Cimbex americana* Leach.
2. *Trogus (Automalus) quebeccensis* Prov.
3. *Perilampus hyalinus* Say.
4. *Tetrachrysis caeruleans* F.
5. *Odynerus molestus* Sauss.
6. *Vesputa vulgaris* L.
7. *Chalybion caeruleum* L.



I. L. WOOD, DEL.

PER. ENGRAVING, MÜN.

MINNESOTA HYMENOPTERA
Plate 1.

In the following pages the order is divided into two groups, the *Chalastogastra*, represented by the first ten families, all included in the one superfamily *Tenthredinoidea* and the *Clistogastra*, which embraces all the remaining superfamilies.

NOMENCLATURE OF WING PARTS IN THE DRAWING OF

Pteronidea ribesi

OLD SYSTEM

COMSTOCK-NEEDHAM SYSTEM

	<i>Veins</i>	<i>Front Wings</i>	<i>Veins</i>
Costal		Costa	
Subcostal		Sc+R+M	
Median		Cubitus	
Anal		1st A+2nd A	
Accessory		3d A and 2d A	
Inferior		Hind margin (not a vein)	
Radial		Rs—R ₃	
Cubital		M—R ₄₊₅ +M ₁	
Subdiscal		m and M ₂	
Transverse costal		Sc ₁	
Transverse radial		Radial cross-vein (<i>r</i>)	
First transverse cubital		Radio-medial cross-vein (<i>r-m</i>)	
Second transverse cubital		Free part of R ₅	
Third transverse cubital		Free part of R ₄	
Basal		Medio-cubital cross-vein (<i>m-cu</i>)	
First recurrent		M ₃₊₄	
Second recurrent		Transverse part of M ₂	
First transverse median		M ₄ +Cu ₁	
Second transverse median		M ₃	
Transverse lanceolate		Free part of 2d A	
	<i>Cells</i>		<i>Cells</i>
Costal		C and Sc ₁	
Subcostal		M	
Median		Cu+Cu ₁	
Lanceolate		1st A + 2d 2d A and 1st 2d A	
		Usually the wing area covered by 1st A, 2d A, and 3d A	
Anal		3d A, or 1st 2d A + 3d A	
Radial		R ₁₊₂	
Appendiculate		Appendiculate	
First cubital		R	
Second cubital		R ₅	
Third cubital		R ₄	
Fourth cubital		R ₃	
First discal		M ₄	
Second discal		1st M ₂	
Third discal		M ₃	
First posterior		M ₁	
Second posterior		2d M ₁	

Hind Wings

<i>Veins</i>		<i>Veins</i>
Costal		Costa
Subcostal		R+M
Median		Cubitus
Anal		Free part of 1st A
Accessory		Free part of 2d A
Radial		R ₅ -R ₃
Axillary		3d A
Cubital		M-R ₄₊₅ +M ₁
Subdiscal		<i>m</i> and M ₂
First transverse cubital		M
Second transverse cubital		R ₄
First recurrent		Medio-cubital cross-vein (<i>m-cu</i>)
Second recurrent		Transverse part of M ₂
	<i>Cells</i>	<i>Cells</i>
Costal		C+Sc ₁
Subcostal		M
Median		M ₂ +Cu+Cu ₁
Lanceolate		1st A
Anal		2d A + 3d A
Radial		R ₁₊₂
First cubital		R+R ₄₊₅
Second cubital		R ₃
Lower discal		M ₁ +1st M ₂
First posterior		M ₁
Second posterior		2d M ₂

KEY TO SUPERFAMILIES.

1. A deep constriction at the base of the first abdominal segment,* conspicuously separating the abdomen from the thorax. 2
 No marked constriction at the base of the abdomen, the thorax and anterior abdominal segments being approximately equal in breadth.
Tenthredinoidea Page 152
2. First abdominal segment* (sometimes also the second) forming a lens-shaped scale or knot (petiole), strongly differentiated from the remaining abdominal segments (gaster) Formicoidea Page 198
 Abdominal segments not strongly differentiated as petiole and gaster 3
3. Mesothorax anteriorly without the free prepectus shown in illustration of Chalcidoidea (Fig. 66) 4
 Mesothorax anteriorly with a prepectus as shown in Fig. 66; usually winged, with venation reduced to a minimum as in Fig. 65; usually less than 3 mm. in length and metallic. Chalcidoidea Page 180
4. Tegulae present, wings usually well developed, sometimes vestigial or lost 5
 Tegulae wanting, wings entirely absent, habitus respectively as in winged forms. 9
5. Pronotum with its hind angles or tubercles tangent to a vertical line drawn tangent to anterior edge of tegulae, touching or underlying tegulae 6
 Pronotum with its hind angles or tubercles always distinctly remote from tegulae. 12
6. Body not flea-like 7
 Body flea-like; trochanters usually composed of a single joint; wings usually with a characteristic venation as shown in Fig. 63. Cynipoidea Page 177

*In all Hymenoptera the segment which is morphologically the first abdominal segment (propodeum) is intimately fused with the thorax, of which it seems to be a part. In this work, the general usage of descriptive writers is followed, and the segment which is apparently the first abdominal segment, though morphologically the second, is uniformly called the first abdominal segment.

7. Wings with at least basal, median and submedian veins present, usually with venation well developed as shown in Fig. 40. Wings usually without veins or with only subcosta and part of radius present, rarely as in Fig. 40, or as in figure of Pelecinus in Packard's Guide.	8
	Serphoidea Page 195
8. Trochanters composed of two joints.	Ichneumonoidea Page 164
Trochanters composed of one joint	14
9. Body not flea-like, not compressed	10
Body flea-like, compressed as in winged forms.	Cynipoidea Page 177
10. Body not densely hairy	11
Body densely hairy	Vespoidea Page 204
11. First abdominal segment elbowed	Ichneumonoidea Page 164
First abdominal segment not elbowed	Serphoidea Page 195
12. Hairs of dorsulum simple, not branched or plumose	13
Hairs of dorsulum branched or plumose	Apoidea Page 223
13. Abdomen with more than three segments visible, segments beyond third not hidden.	Sphecoidea Page 215
Abdomen with three segments visible, segments beyond third hidden	Chrysoidea Page 203
14. Cutting edge of mandibles turned inward, their tips meeting or overlapping when mandibles are flexed toward mouth.	Vespoidea Page 204
Cutting edge of mandibles turned outward, their tips usually neither meeting nor overlapping when mandibles are flexed toward mouth.	Ichneumonoidea Page 164

CHALASTOGASTRA

TENTHREDINOIDEA

This is that part of the Hymenoptera known as the Phytophaga, Phyllophaga, Tenthredinoidea or Saw-flies and Horn Tails or Tenthredinoidea and Siricoidea. Lately, S. A. Rohwer¹ has split up this complex group into four Superfamilies—Megalodontoidea, Orysssoidea, Siricoidea and Tenthredinoidea. The first of these superfamilies is represented in the following pages by the Megalodontidae, Cephidae and Xyelidae, the second by the Oryssidae, the third by the Xiphidriidae and the Siricidae, the fourth by the Cimbicidae, Argidae, Diprionidae, Tenthredinidae and Pterygophoridae.

The suborder includes all those individuals which feed upon vegetable tissue, either directly as in the case of the saw-flies which eat practically the entire leaf, or indirectly as with the gall flies, where by the injection of some active irritating or stimulating agent, or by similar effect induced by the presence of the egg or eggs or larva in the plant tissue, produce distorted growths in and upon which the larva feeds until maturity. The galls on willow, oak, rose, goldenrod and some of the other plants and trees are examples of these growths.

Many members of the group are injurious, and in some of the forms the ovipositor is modified to form a pair of saw-like plates lying inside of, and protected by a sheath. The insects so characterized, are compact with the thorax and abdomen about equal in trans-

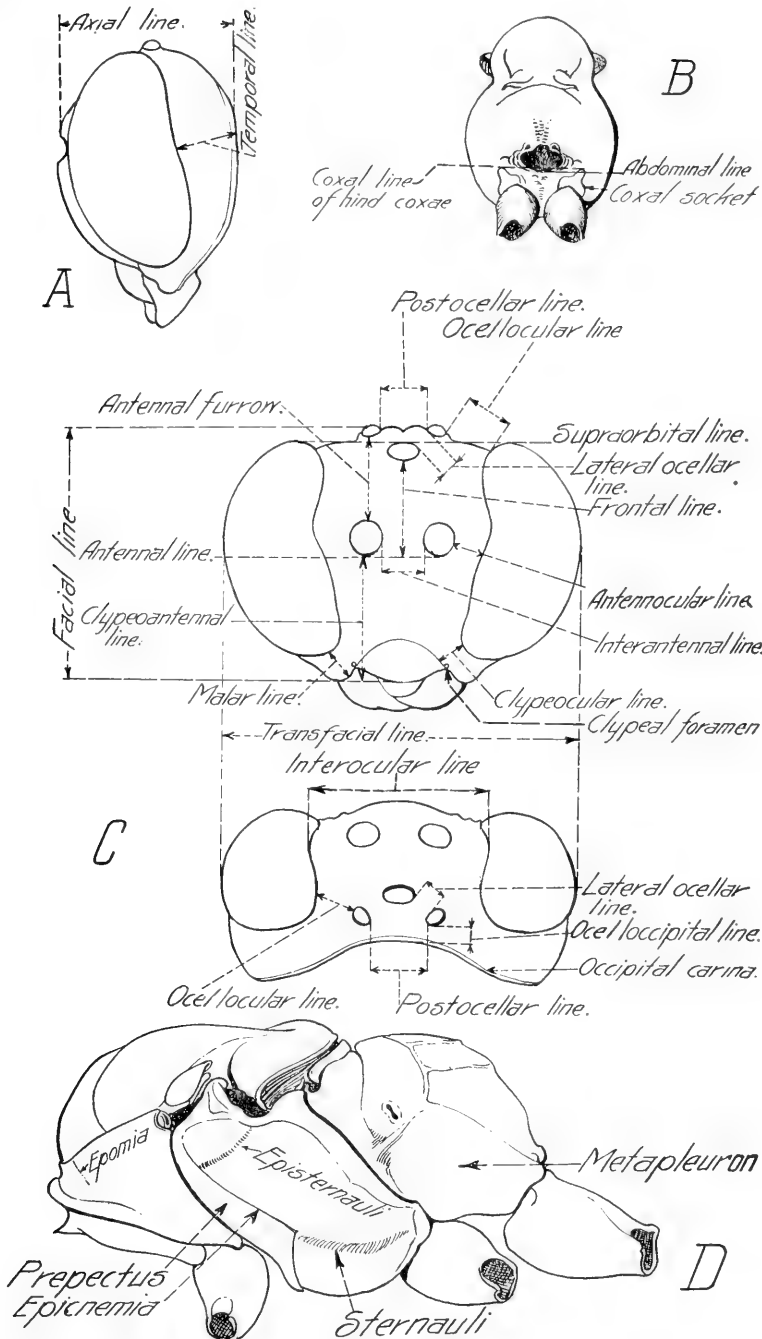


Fig. 27. *Exochilum morio*: different views of head, thorax and propodeum. From Connecticut Hymenoptera.

verse diameter. The abdomen is closely applied to the thorax by its entire width. This condition is described by the expression "abdomen sessile" (not stalked). The wings are folded over the abdomen when the insect is not in flight.

The larvae are unmistakable; they are either slug-like and slimy, or resemble caterpillars very closely with the exception of having more than five pairs of prolegs.

Larvae of this group need not be confused with caterpillars of Lepidoptera, for saw-fly caterpillars have from eighteen to twenty-two

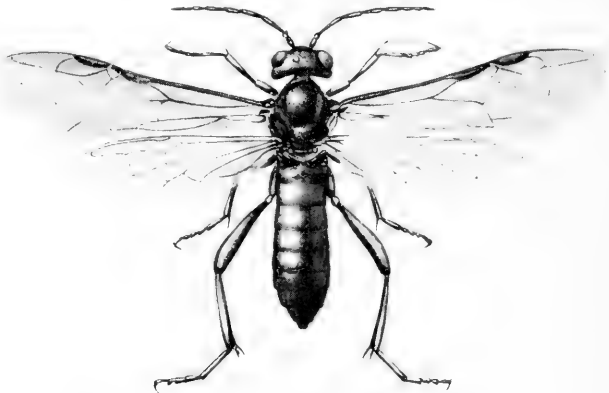


Fig. 28. *Macrophya cassandra* Kirby: female.

prolegs and these have no circling of hooks as in Lepidoptera. The former larvae move more slowly than the true caterpillars of the Lepidoptera and they frequently assume grotesque postures never taken by true caterpillars. When disturbed, they sometimes curl up, lying on their sides. They are in some species covered with slime, or exude a disagreeable liquid, and often change their color during larval life.

Tenthredinid larvae generally change to the pupal stage in a cocoon. There may also be an outer cocoon, hard and coarse, and within that, one of finer texture.

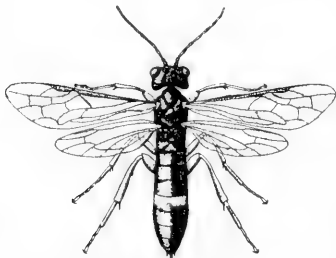


Fig. 29. *Emphytes mellipes* Norton; female.

This group may perhaps be regarded as a connecting link between the Lepidoptera and the Hymenoptera.

The superfamily contains the most injurious individuals of the order. The species are largely confined to the temperate zone.

MEGALODONTIDAE

Hind margin of the pronotum, or collar, straight or nearly so, being nearly the shortest distance between the fore margins of the tegulae; dorsulum never extending much beyond the fore margins of the tegulae; proepimeron wanting; first perapterum wanting; fore tibiae with two spurs.



Fig. 30. *Sterictiphora johnsoni* MacGill; male.

Inhabit woods, flying in the sun, settling on leaves and occasionally, but rarely on flowers. Larvae smooth, cylindrical, with six short articulate and no prehensile legs. Feed on leaves of trees and inhabit webs of their own making. Pupa changes in a silken cocoon on the stem of the tree it inhabits, or on the ground. *Itycorsia discolor* Cress, and *Pamphilus persicus* MacG. occur in Minnesota.

CEPHIDAE

Hind margin of the pronotum, dorsulum and proepimeron as in *Megalodontidae*; first perapterum present and seen a short distance below the tegulae as a small free plate; fore tibiae with one spur; basal joints of the flagel separate; intercostal vein wanting, radial cell with one cross vein; species slender and elongate.

Cephus pygameus Linn., is known as a wheat-stem borer, an introduced insect; in Europe it attacks corn. Another form, *Janus integer* Nort., bores in pith of currant. Another works in blackberries, entering at the bottom and boring upward.

Janus abbreviatus Say, is a Minnesota species.

XYELIDAE

Hind margin of pronotum, dorsulum, proepimeron and first perapterum as in *Cephidae*; fore tibiae with two spurs; basal joints of the flagel consolidated into a long basal joint; intercostal vein present, radial cell with two cross veins; species robust. Larva footless.

Imagoes appear early in the year, February, March and April, deposit their eggs and disappear, so that few specimens are taken and only the common forms known. Newman says of the group: "Inhabits fir trees, occasionally settling on umbelliferous plants." Ent. Mag. II, p. 408, 1834. Dyar, however, is reported as finding

one species upon hickory and butternut in New Jersey and the larva of another species is reported as found upon the leaves of elm. The larva of *Xycla minor* has been found on pine. The larvae feed on the leaves of the numerous elms found along the walks on the College Campus at Saint Anthony Park. The adults are very inactive, so much so, in fact, that they will lie still and allow themselves to be crushed under foot on the walks. When they are disturbed in such a way as to be compelled to use their wings, they have a slow lumbering

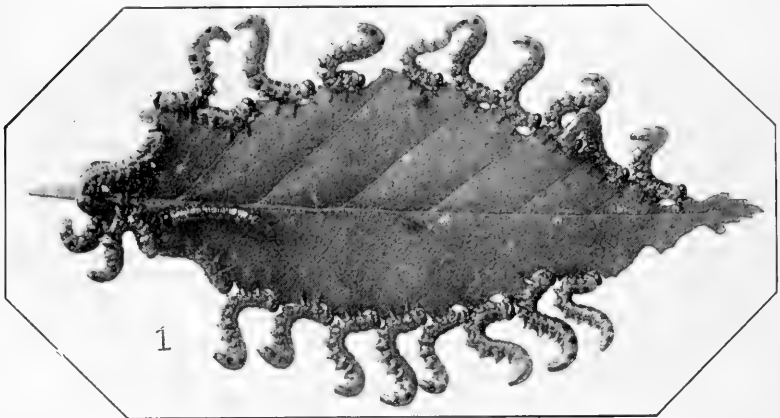


Fig. 31. Tenthredinid larvae, *Craesus latitarsus* Nort. on birch, showing a characteristic attitude.—From Hymenoptera of Connecticut.

flight and soon alight again; that is, the generalized condition of their wings, as regards the number and arrangement of their veins and trusses is confirmed by field observations, and proves that this insect not only has wings that are poorly fitted for a rapid flight, but that in fact it is an extremely poor flyer.

This is a small family embracing five genera and a limited number of species which are confined mainly to the American fauna. It is easily separated from all other Hymenoptera by the presence in its wing of the free part of the vein R_2 . The family contains, at least so far as their wing venation is concerned, the most generalized Hymenoptera known.



Fig. 32. *Cimbex americana* Leach. Another position assumed by saw-fly larvae.—From Hymenoptera of Connecticut.

ORYSSIDAE

Hind margin of the pronotum strongly curved, dorsulum extending well beyond the fore margins of the tegulae; metanotum concealed, metapostnotum present and large; antennae inserted much below the apparent clypeus; propodeum not divided; proepimeron wanting; fore wings with two cubital cells.

Only one genus occurs in this family, *Oryssus*, of which there are but a few rare species. *O. sayi* West, is found in Minnesota.

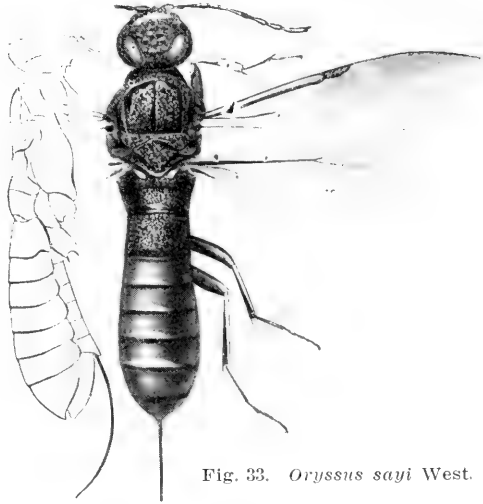


Fig. 33. *Oryssus sayi* West.

SIRICIDAE

Hind margin of pronotum and mesonotum as in *Oryssidae*; metanotum always present, altho the metapostnotum is sometimes concealed; antennae inserted above the clypeus; fore wings with more than two cubital cells; scutel completely separated from the mesoscutum by a suture; proepimeron wanting, fore tibiae with one apical spur; sheath exerted beyond the tip of the abdomen; cubitus joining the basal vein much below the costa; notauli wanting, mesoscutum with oblique sutures from the tegulae to the fore margin of the scutel; pronotum large, perpendicular anteriorly and angulate laterally; apex of abdomen with a triangular plate; fore wings without an intercostal vein.

The ovipositor is held projecting backward from the extremity of the body. Looks like a powerful sting. It is much longer than it appears, as it is attached not to apex of body but far forward, to the under surface. It consists of a pair of elongate sheaths, which are easily separable though they wrap together and enclose a slender tube. This tube is rigid and quite straight; tho appearing solid, it is really composed of two very perfectly adjusted laminae and a third arched piece or roof. The two lower laminae are called spiculae; they are serrated or grooved in a peculiar manner

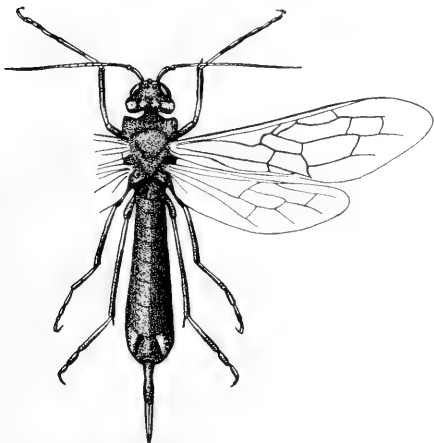


Fig. 34. *Urocerus albicornis* Fab.

near the tip, and altho so closely adjusted to the borer or upper piece of the tube as to appear to form one solid whole with it, they are said to be capable of separate motion.

The Siricidae are the *Uroceridae* of authors. Something like fifty species are known in this country, amongst them occurs the well-known Pigeon Tremex, *T. columba*.

The females of this species have a boring ovipositor or horn, projecting from the abdomen. With this, a hole is drilled in solid wood and an egg is deposited therein. This pest attacks apple, maple, beech, oak, elm, pear and other trees; is apparently partial to the elm. It is kept fairly well in check by parasites. Females, when egg-laying, are sometimes unable to withdraw their ovipositors and are prisoners until death relieves them. The larva, when full grown, is 1½ inches long; it transforms in a cocoon made of silk and fine chips, and when ready to emerge, gnaws through the bark and flies away.

The genus *Sirex* is a wood borer and may pass so long a period in wood that it is brought into a house in furniture. An instance is cited where from wood, supposedly brought from Canada and made into a house in England, *Sirex* emerged, to the great terror of the occupants. *Sirex* is often found in dried wood incased in metal, and has been known to gnaw its way through the metal. *Tremex columba* L., *Sirex edwardsii* Brulle, and *Urocerus albicornis* Fab. occur in this state.

XIPHYDRIIDAE

Hind margin of pronotum, mesonotum, metanotum, metapostnotum, antennae, forewings, scutell, proepimeron, spurs of fore tibiae, exsertion of the sheath and junction of the cubitus with the basal vein, as in *Siricidae*; notauli present; mesoscutum without oblique sutures from the tegulae to the fore margin of the scutell; pronotum very short medially and not angulate laterally; apex of abdomen normal; fore wings with an intercostal vein.

Larva without feet. Inhabits and lives on the dead or dying wood of various trees. Pupa changes in the same situation.

Xiphydria maculata Say and *X. erythrogastra* Ashm. are found in Minnesota.

CIMBICIDAE

Hind margin of pronotum, mesonotum, metanotum, metapostnotum, insertion of antennae and number of cubital cells in fore wings as in *Siricidae*; scutell never completely separated from the mesoscutum by a suture, the suture always wanting laterally, proepimeron present; fore tibiae with two apical spurs; cubitus joining or touching the basal vein very close to the costa; mesoprescutum always present; first perapterum present; abdomen sharply angled laterally, the tergites, laterally with a dorsal and ventral aspect; antennae clavate.

The American Sawfly, or Elm Sawfly, *Cimbex americana*, is a common species of general distribution, feeding on willow, basswood, elm, birch and allied trees. The yellowish green larva has a black

stripe along the middle of the back. Eggs are laid in June and the winter is spent below the surface of the ground, in the larval stage, not changing to pupa until spring. This species, normally destructive, has been observed to prey upon Gypsy Moth caterpillars (The Gypsy Moth, Report of Forbush and Fernald, Mass. State Bd. Ag. 1896, p. 379). For an illustration of the larva of this form see Fig. 32. The adult is shown on colored plate 1.

ARGIDAE

Agrees with the preceding description of *Cimbicidae* except as follows: Abdomen not sharply angled laterally; antennae not clavate; sternauli or a suture separating the mesosternum from the mesoepisternum, present; hind coxae adjoining or nearly so; antennae three jointed.

The Purslane Sawfly, *Aprosthem a zabriskei* Webster, occurring commonly in Minnesota, is an interesting form in that it is sometimes quite effective in checking the purslane. The eggs are deposited by the female in the edges of the leaves. The larvae work within the leaf between the two surfaces. The pupal stage occurs in the ground and lasts about seven days.

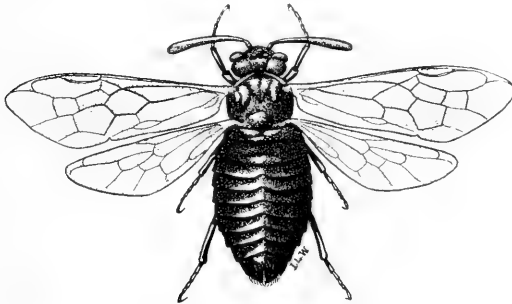


Fig. 35. *Arge scapularis* Klug.

Other Minnesota species are *Arge caerulea* Nort., the larva feeding on white birch; *A. clavicornis* F., *A. humeralis* Beauv., *A. scapularis* Klug., *A. mcLeayi* Leach, *A. pectoralis* Leach, *A. dulciana* Say, and *Sterictophora johnsoni* MacG.

DIPRIONIDAE

Agrees with the preceding description of *Argidae* except as follows: sternauli wanting; antennae more than six-jointed, furthermore, the first discoidal cell is not petiolate, the mesoepimeron is divided into two plates with the sculpture of the dorsal one similar to that of the mesoepisternum, proepisternum not divided into two plates; antennae many jointed, serrate in the female, pectinate in the male.

The larva feed on various pines and on fir. *Diprion abboti* sometimes defoliates branches of pine. The species has the habit of throwing back head and tail when disturbed. *D. abietes* feeds, in companies, on fir leaves until full grown. The whitish, tough cocoons often adhere to the leaves until the following season. Both of these species may be quite destructive. *D. pinetum*, occurs in Minnesota, the larva feeding on pine.

TENTHREDINIDAE

Agrees with the preceding description of **Diprionidae** except as follows: Mesopisternum not divided into plates; proepisternum divided into two plates; antennae seven to twelve-jointed, never serrate or pectinate.

Characterized by a large number of species, at least 2,000 being known, amongst them some of our most common pests, for example, the pear and cherry slug, larch sawfly, currant worm, the imported and native, the former being green and black, spotted in the adult larval stage, while the latter, with the exceptions of its black head, is all green. In this family occur the rose slugs, raspberry slug, pine sawfly and other pests.

Eggs are laid in slits cut by females in the leaf of host plant; in currants, gooseberries and some other plants the eggs are laid on the under side of the leaf. The larvae of some of the species "skeletonize" the leaf, eating only the softer tissues, while others, like the currant

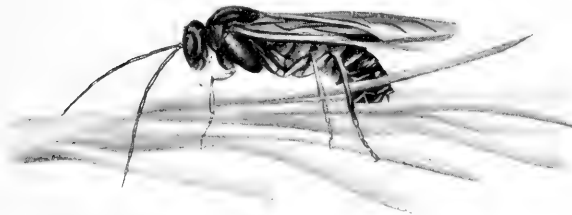


Fig. 36. *Lygaconematus crichsoni* Hartig. The Larch Saw Fly.

the pear and cherry slug, larch sawfly, currant worm, the imported and native, the former being green and black, spotted in the adult larval stage, while the latter, with the exceptions of its black head, is all green.

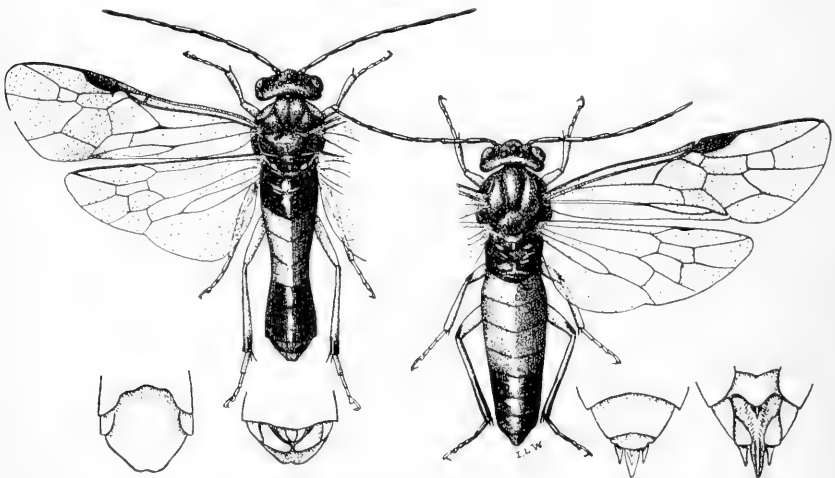


Fig. 37. *Lygaconematus crichsoni* Hartig. The Larch Sawfly, male and female and tips of abdomens.

worm, eat the leaf entire. When full grown, the larvae make an oval parchment-like cocoon which may be attached to host plant or just below the surface of the ground.

Several species work on pine, others on strawberries, one on alder—on *Cornus*, oak, maple, etc. Two attack willows. One species is found on butternut. Another bores into the leaf stem of sugar maple. At least one species is known to work on cranberry. Still others make galls and two or more are known to be leaf rollers. One feeds on poison ivy, and another feeds on sweet potato.

The family is referred to as "sawflies" because the females have saw-like ovipositors, the ovipositor represented by a pair of stylets, each serrate on outer margin.

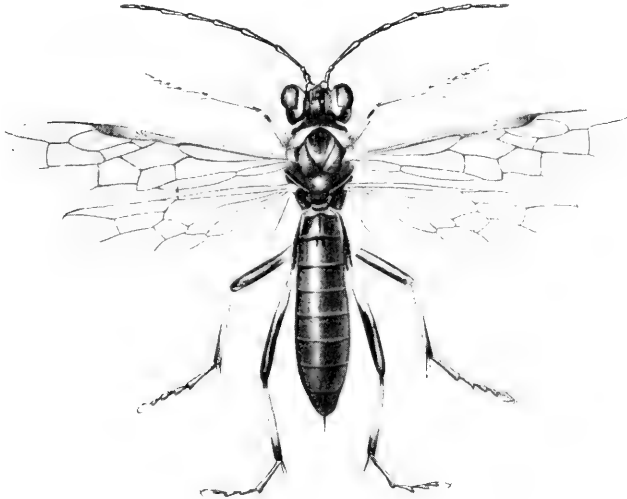


Fig. 38. *Tenthredella lobata* Norton: female.

The larch sawfly, *Lygaconematus crichsonii* is a menace to the tamaracks of the northern part of the United States and Canada.

The effect of the attacks of the pear and cherry slug may be so severe as to cause the leaves of these trees to brown and fall to the ground in the middle of the summer. Fortunately, this pest of the orchardist is easily destroyed, yielding readily to any of the arsenical insecticides, to hellebore or pyrethrum, to dusting with air-slaked lime, or even with road dust.

The imported or common currant worm occurs in this family, a well-known pest of currants and gooseberries, stripping the leaves from the bushes if not promptly checked. It is particularly destructive

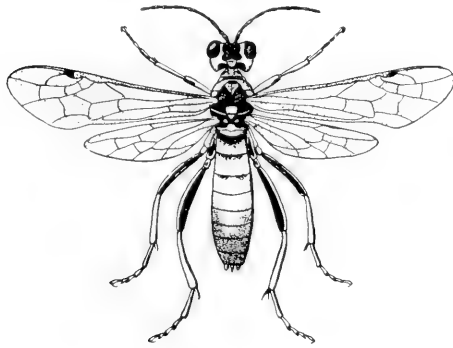


Fig. 39. *Tenthredella verticalis* Say: male.

ventralis Say, *Lygaonematus erichsonii*; Hartig (larva feeds on European and American Larch).

in that its attacks are frequently not observed until too late to save the foliage. The yellow-spotted willow slug, *Nematus ventralis* Say, is a common pest of the willow. The larva is dark with yellow spots.

Minnesota species: *Emphytes mellipes* Nort., *Pteronidea ribesi* Scop., *P.*

Allantus basilaris Say, *Macrophya lineata* Nort., *M. cassandra* Kirby, *M. fuliginosus* Nort., *Croesus latitarsus* Nort., *Tenthredella grandis* Nort., *T. rufopectus* Nort., *T. lobata* Nort., *T. tricolor* Nort., *T. verticalis* Say, *Loderus albifrons* Nort., *Dolerus apricus* Nort., *D. aprilis* Nort., *D. bicolor* Beauv., *D. similis* Nort., *D. unicolor* Beauv., *Tomostethus bardus* Say. Viereck took *Fenusa* sp. Aug. 13 in St. Louis County, and *Schizocerus* sp. in Sept. in Rock County.

PTERYGOPHORIDAE

Agrees with the description of *Cimbiidae* except as follows: First perapterum present, sternali or the suture separating the mesosternum from the mesoepisternum wanting.

Acordulecera dorsalis Say, black, with white feet, is said to be common in Indiana. A specimen in our collection is labelled "Va."

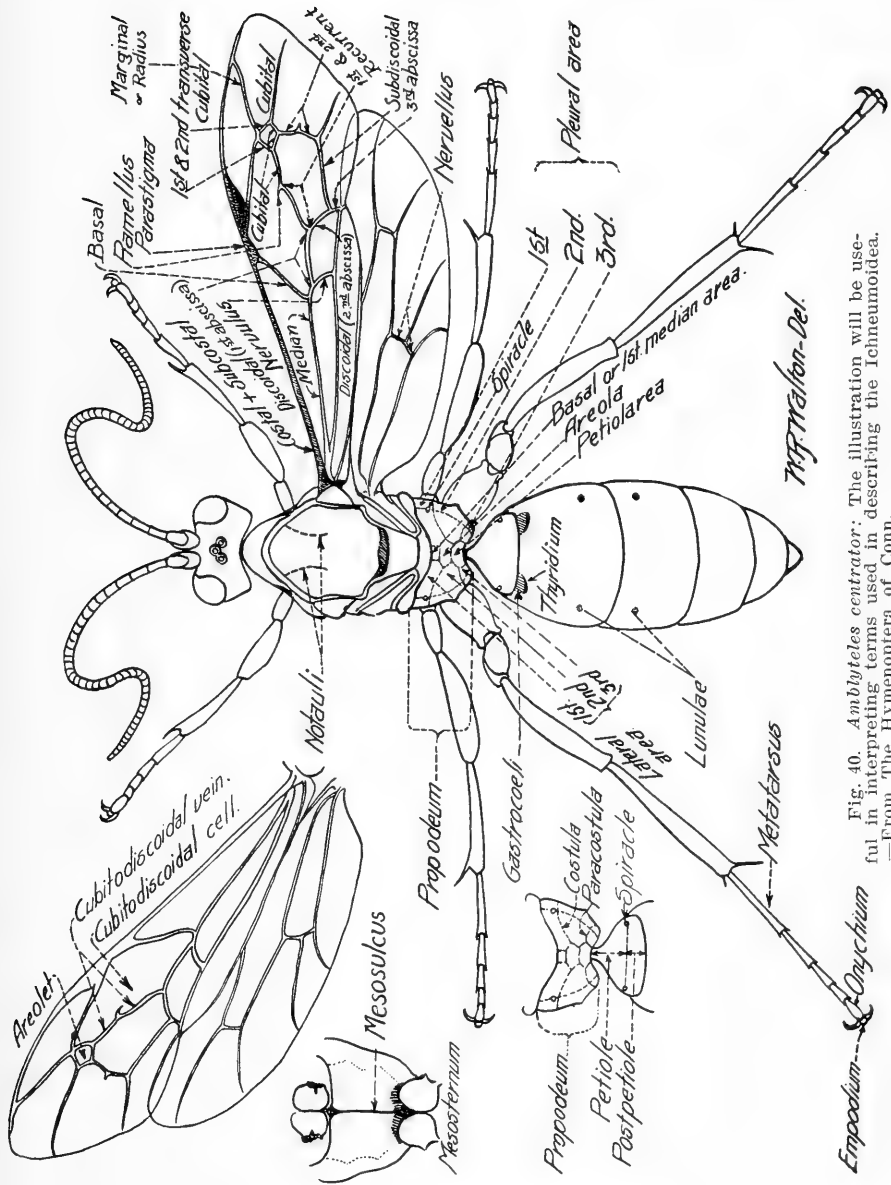


Fig. 40. *Amblyteles centrator*: The illustration will be useful in interpreting terms used in describing the Ichneumoida. —From The Hymenoptera of Conn.

NOMENCLATURE OF WING PARTS IN THE DRAWING OF

Amblyteles centrator

OLD SYSTEM	COMSTOCK-NEEDHAM SYSTEM
<i>Veins</i>	<i>Veins</i>
Costa subcostal (In the Ichneumonoidea considered in this work these veins are usually seemingly but not actually coalescent.)	Costa (C)+Sc+R+M
First transverse cubital.	<i>r-m</i> and Rs
Second transverse cubital	R ₄
Cubital	M ₁₊₂ and R ₄₊₃ + M ₁
First recurrent	M ₃₊₄
Second recurrent	Transverse part of M ₂ or first abscissa of M ₂
Basal	M and <i>m-cu</i>
Subdiscoidal	<i>m</i> and M ₂
Abbreviated cubital or stump	M
Externomedial	Cu
Discoidal	M ₄
} 1st abscissa	M ₂
} 2d and 3d abscissa	M ₄ +Cu ₁
Transverse median of fore wings, or nervulus	
Marginal or	Radial cross-vein
} 1st abscissa	
} 2d and 3d abscissa	R ₃
Transverse median of hind wings, or nervellus	M ₃
<i>Cells</i>	<i>Cells</i>
Areolet	R ₄₊₅
Cubitodiscoidal	1st R ₁ +R+M ₄

CLISTOGASTRA

SUBORDER ICHNEUMONOIDEA

Trochanters are composed of one or two joints, the first abdominal segment is elbowed and the cutting edge of the mandible, in some groups, is turned outward. Wings usually with at least the basal, median and submedian veins present; body never flea-like; pronotum with its hind angles or tubercles tangent to a vertical line drawn tangent to the anterior edge of the tegulae and touching or underlying the latter; tegulae and wings usually present, sometimes vestigial or lost. Where the tegulae and wings are wanting, the habitus is as in the winged forms, the body is not densely hairy and the first abdominal segment is elbowed; mesothorax anteriorly without a free prepectus, first and second abdominal segments never developed into a lens-shaped scale or into a node.

This is the most important group of Hymenoptera, in that it contains the bulk of the useful parasites for which the order is noted.

There are over 1,200 species of the suborder in Great Britain alone, and probably more than 6,000 described species. Unquestionably, there are more species still unknown. The tropics, for example, offer a field practically unworked.



Fig. 41. Cocoons of a Vipionid *Apanteles* (*Protopanteles*) *congregatus*, Say on Young Tobacco Worm. Natural size.—Courtesy of the Conn. Ag. Exp. Sta.

The larvae are all parasitic, principally on caterpillars, destroying enormous numbers of these pests. Some attack spiders.

Attacks by these parasites are not confined to land species, for one European form, *Agriotypus armatus*, is aquatic, going under the water and remaining there for a considerable period in order to lay its eggs on larvae of caddis flies.

A single genus, *Aphidius*, contains parasites on plum louse, currant, rose and wheat lice, as well as lice infesting cherry, willow, poplar and cabbage.

Breathing in the larval stage is effected by osmosis between the body of the parasite and the lymph or blood of its host in which it lies.

VIPIONIDAE

Cutting edge of mandibles turned inward, their tip meeting or overlapping, when the mandibles are flexed toward the mouth; mesothorax with its sternum and pleurae, or at least the latter, not divided into an anterior and posterior portion by the presence of a carina or suture, in short, without a prepectus; second and third tergites fused as is evidenced by the apparent second tergite having two pairs of spiracles.

Found in willow galls; parasitic on some hairy caterpillars, cottony maple scale, etc.

Neopius carinaticeps Gahan has been reared from *Agromyza* mines in *Hordeum*. *Opius* (*Eutrichopsis*) *dimidiatus* Ashm. is a parasite of *Agromyza pusilla*, and *O. foveolatus* Ashm. parasitizes *Pegomyia*.

Minnesota species: *Protapanteles* sp. reared from *Agresthia alternatella* by S. Marcovitch. Also taken Sept. 15 at Lanesboro. A large number of *Apanteles* were reared in our insectary in the 80's and are in the collection, but without labels to indicate the locality of collecting. Specimens, however, were taken by Viereck at Lanesboro, Sept. 15, 1913. *Atanycolus* is found here (taken Sept. 11 in Rock Co. on sunflower) as are also the genera *Habrobracon*, *Iphiaulax* (*Monogonogastra*), *Microbracon* (Fillmore Co. in Sept.), *Cardiochiles*, *Mirax* and *Opius*, representatives of the latter genus being taken in Itasca Co., Sept. 1, 1913.

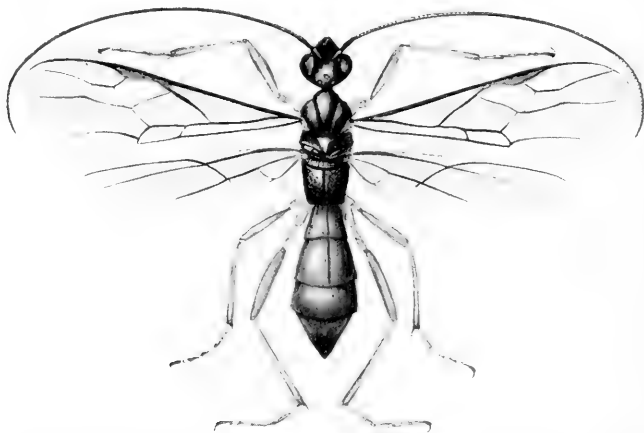


Fig. 42. *Aleiodes abdominalis* Cress.: female. Family Braconidae.

ALYSIIDAE

Second and third tergites fused as is evidenced by the apparent second segment having two pairs of spiracles. Cutting edge of mandibles turned outward, their tips neither meeting nor overlapping when they are flexed toward the mouth; mesothorax with its sternum and pleurae, or at least the latter not divided into an anterior and posterior portion by the presence of a carina or suture, in short without a prepectus.

This family contains parasites on various injurious forms, the cabbage maggot, horn fly, wheat louse, etc. Dipterous larvae appear to be its choice.

Coelinidea ferruginea Gahan, is a parasite of *Meromyza americana*. *Mesocrina pegomyiae* was reared from *P. brassicae* and originally described from Minnesota by Brues. The same is true of *Aphaereta pegomyiae* Brues, also reared from *P. brassicae* in our laboratory. Specimens of *Phaenocarpa* were taken Aug. 14 at Duluth; *Ischnocarpa* specimens were captured Sept. 3 in Itasca Co., and representatives of *Dacmusa* were taken in Roseau Co., Aug. 19. *Aspilota* has been taken in Fillmore Co., and *Anisocyrta* in Roseau Co.

STEPHANIDAE

Second and third tergites not fused. All known forms winged. Wings with a distinct costal cell, i. e., with four cells running to base of wings. Frontal line longer than clypeo-antennal line, or antennae inserted below middle of face; second division of dorsum of abdomen with only one pair of spiracles; propodeum hardly extending beyond base of coxae, upper edge of hind coxal sockets or coxal line close to lower edge of abdominal socket or abdominal line; mesothorax as in *Alysidae*.

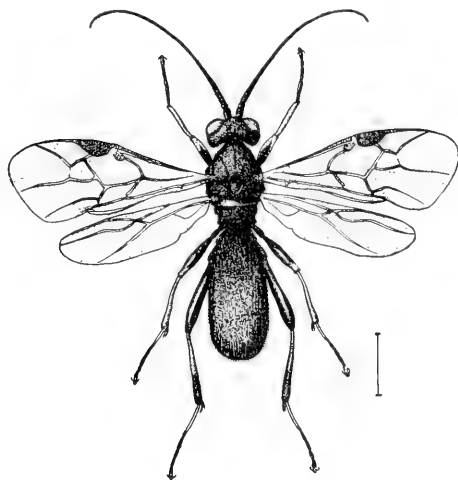


Fig. 43. *Chelonus sericeus* Say, a Braconid.

All rare insects; but little known of their habits. Ashmead says (Proc. U. S. Nat. Mus. Vol. XIII p. 149) "The cephalic and venational characters of this curious group recall those to be found in the family *Oryssidae*, and I can not help but think the two families, in ages past, had a common ancestry."

BANCHIDAE

Second and third tergites not fused. Wings without a distinct costal cell, i. e., with but three cells running to base of wing. Spiracles of first and second dorsal segments in or before middle. Fore wings with two recurrent veins, the first represented by the cubito discoidal vein, first abscissa of cubitus wanting; frontal line shorter than clypeo-antennal line; second division of dorsum of abdomen and propodeum as in *Stephanidae*.

The genus *Banchus* is represented in Minnesota.

BRACONIDAE

Fore wings with one or two recurrent veins; edges of fused second and third dorsal abdominal segments may or may not meet beneath. First abscissa of cubitus wanting or present. Caterpillars are often found more or less covered by tiny white cocoons of Braconid parasites, the adult larvae having left the cocoons of their host and spun their cocoons on the surface of the body of their dying victim.

Several hundred species are known to occur in this family, for the most part highly colored. The larvae are parasitic in (rarely on) the bodies of larvae or of pupae of other insects. They have also been reared from the imagoes. One species is known to attack ants (there are but few Hymenopterous parasites on Formicids.) Of insect internal parasites, it may be said that the victim is not eaten, the parasite feeding on the lymph within the body either by means of its mouth or

by endosmosis. The host shows no sign of sickness at first, and eats voraciously. But generally, when the period arrives at which normally the larva would change to a pupa, the host sickens and dies.

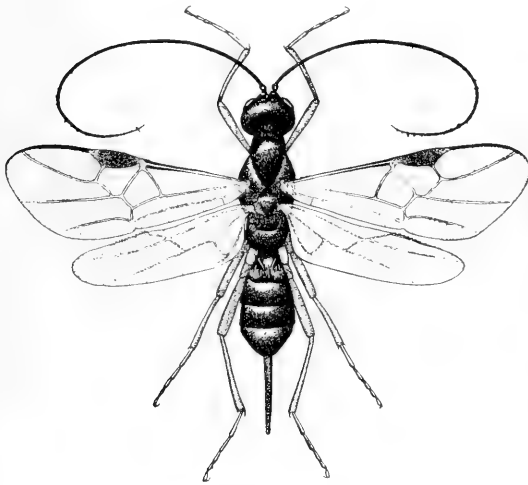


Fig. 44. *Brachistes*, sp., female. Bred from borers in poplar.



Fig. 45. *Brachistes*, sp., male. A Braconid.

To indicate the fecundity of these insects, and by inference, their usefulness, we might cite the case of *Microgaster*. As many as 1,200 specimens of this genus have been raised from a single Lepidopterous larva.

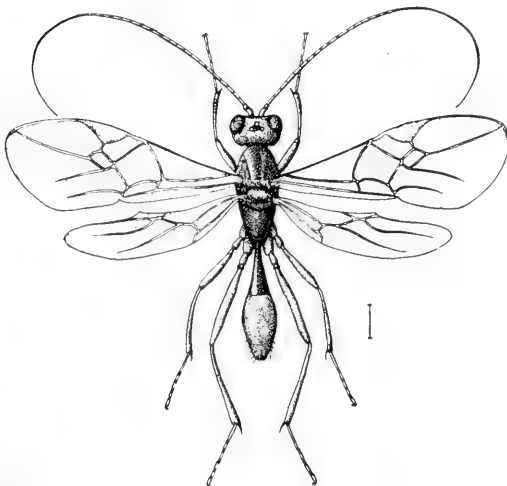


Fig. 46. *Metcorus*, sp.

The following are found in Minnesota: (*Blacus*) *Eubadizon gracilis* Brues, *Ichneuti-
dea secunda* Roh., reared from larvae of the Purslane Sawfly by S. Marcovitch, also taken in Rock Co., Sept. 9; *Microdus simillimus* Cress, *Chelonus sericeus* Say, (*Chelonus*, sp. Sept. 10 in Rock Co.), *C. elec-*

tus Cress., *Ascogaster rufipes* Prov., *Schioprymnus texanus* Cress., *Urosigalphus robustus* Ashm., *Earimus limitaris* Say, *Aleiodes abdominalis* Cress. and the genera *Microtypus*, *Meteorus*, (St. Louis Co., Aug. 13), *Orgilus*, *Brachistes* and *Heterospilus*. An unidentified *Aleiodes* was captured in Roseau Co., Aug. 19, and *Macrocentrus*, sp. taken near Duluth, Aug. 14, and *Blacus*, sp. Sept. 1, at Itasca Park. *Triaspis* was found in Rock Co. in Sept.

CAPITONIIDAE

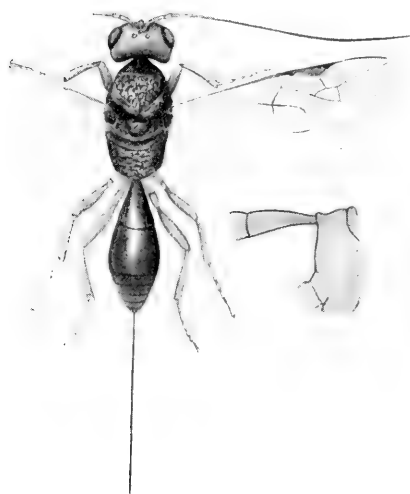


Fig. 47. *Capitonius ashmeadi* D. T.

C. ashmeadi D. T. found in Minnesota has been bred from *Sternidius alpha*, living in the pith of *Rhus glabra*.

EVANIIDAE

Abdomen inserted high up on propodeum in middle or above middle of latter, upper edge of hind coxal sockets or coxal line remote from lower edge of abdominal socket or abdominal line. Abdomen always with more than two dorsal segments.

The Evaniids are called by Comstock, "ensign flies" because they carry the abdomen aloft like a flag.

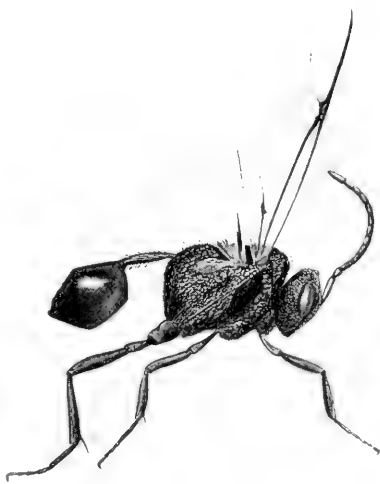


Fig. 48. *Hyptia harpyoides* Bradley

Abdomen inserted high up on propodeum, in middle or above middle of latter; upper edge of hind coxal sockets or coxal line remote from lower edge of abdominal sockets or abdominal line. Mesothorax with its sternum and its pleurae, or at least the latter, more or less divided into an anterior and posterior portion by the presence of a carina or suture, in other words with a prepectus as indicated by Snodgrass. Second and third tergites as in *Alysiidae*.

Only one genus, *Capitonius*, found in the United States. See Rohwer's key to the species, Canadian Entomologist, Vol. XLVI, p. 316.

A striking peculiarity of the family is noted in the fact that the abdomen is attached to the top of the metathorax, not to the posterior end. The abdomen is compressed and has a very slender base.

Certain species in this group deposit their eggs in egg capsules of cockroaches, and have been reared from them. They are met with where cockroaches are abundant, and are reported to have been observed on board ships, where, quite commonly, roaches are a pest. *Gasteruption incertum* Cress., *Odontaulocus abdominalis* Cress., *Hypitia harpyoides* Bradley, and the genus *Aulacus* occur in Minnesota.

TRIGONALIDAE

First abdominal segment broadened or bulbous at apex, not cylindrical. Costal cell distinct.

A family of parasites living in nests of *Polistes* and *Vespa* and preying upon the occupants.

Geo. W. Taylor reports (Can. Ent. XXX p. 14, 1898) taking nine male Trigonalids in the vicinity of a large nest of *Vespa occidentalis* in October. He says "The day was dull and the wasps sluggish, but quite a number of males and perfect females were crawling about around the entrance to the nest. Among the wasps were some specimens of a conspicuous yellow and black Hymenopteron."

These were identified as *Trigonalys canadensis* Hargm.

ICHNEUMONIDAE

As in **Trigonalidae**, but costal cell obliterated by approximation of costal and sub-costal veins.

Typical parasites of many forms of insect life, such as army worms, cutworms, and other injurious *Lepidoptera*. As parasites, however, their attacks are by no means limited to the butterflies and moths, for they also prey upon certain *Coleoptera* and *Hymenoptera*, as well as on plant lice. The larvae of *Phryganids*, al-

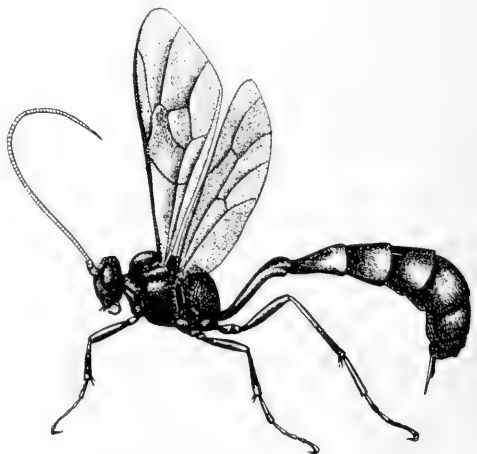


Fig. 49. *Thyreodon brullei* Vier.

tho living in the water, do not escape them, and some species attack spiders.

Generally, all have long slender bodies, ovipositors sometimes very long and protected by a sheath. Eggs are laid either upon the outside or within the caterpillar or other larva. When hatched, the Ichneumon grub devours the fatty portions of its victim, the latter gradually



Fig. 50. The parasite, *Lysiphlebus*, sp. attacking grain plant louse. From life.

growing weaker and dying about the time it would normally pupate. The parasite lives largely by the absorption of the lymph and blood of its host.

The genus *Aphidius*, an Ichneumon preying upon plant lice, is extremely useful to the agriculturist. The species are all small. Some prey upon aphids on oats, others on different forms of wheat aphids. Usually a parasitized aphid is swollen and globular in marked contrast to other non-parasitized aphids. The method of attacking plant lice on the part of this genus is interesting; "the female alights upon a leaf and runs about amongst the plant lice. When she has selected one in which to oviposit, she stands with her head toward it, and bending her abdomen under her thorax, between her legs, she darts her ovipositor forward into the body of the aphid." (Comstock). In this connection see the illustrations made in our laboratory, Figs. 50, 51 and 52.

Another interesting form is *Megarhyssa* (*Thalessa*) and the genus is exceedingly useful in destroying larvae of injurious borers belonging to the family *Siricidae*. In order to reach these borers in the wood, the ovipositor is of extreme length (six inches). It is bowed over the back of the parasite, the tip being thus brought vertically down on the wood, the latter is pierced or drilled and the egg laid in the burrow of the borer. The injurious *Tremex* is the chief sufferer.

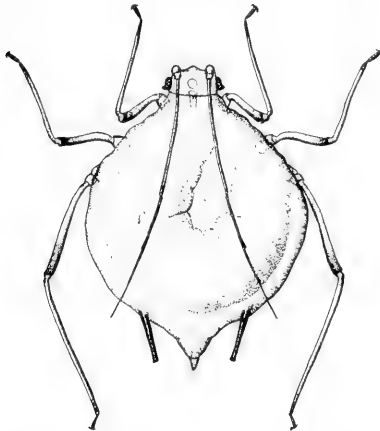


Fig. 51. A grain plant louse, *M. granaria*, in which the full grown parasitic larva can be seen.

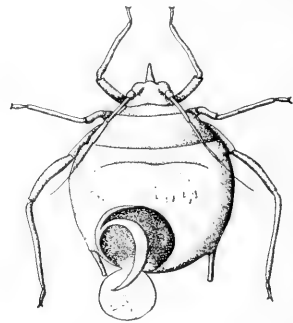


Fig. 52. A "green bug" killed by a parasite.

Minnesota species: *Thyreodon bruellei*, var. *transitionalis* Vier. *T. morio* Fab., *Automalus quebecensis* Prov. (see colored plate 1). *Ameloctonus fugitivus* Say, *A. clisiocampae* Weed, *Heteropelma flavicornis* Say, *Exochilum fuscipennis* Nort., *E. tenuipes* Nort., *Eremotylus macrurus* L., *Ophion slossonae* Davis, *O. bilineatus* Say, *O. bifoveolatus* Br., *Enicospilus purgatus* Say, *Estochus laevis* Cress., *Anomalon lactatorius* Fab. (Roseau Co., Aug. 19), *Homotropus bicapillaris* Walsh, *Phacogenes vincibilis* Cress., *P. discus* Cress., *Glypta erratica* Cress., *Centetarus tuberculifrons* Prov., *Theronia allantae fulvescens* Cress., *Itopectis marginatus* Prov., *I. tenuicornis* Cress. (Sept. 1, Itasca Park), *Scambus indagator* Walsh, *S. monta* Cress., *Pimplidea pedalis* Cress., *Odontomerus mellipes* Say, *Eremochila indagator* Walsh, *Tromatobia scriptifrons* Cress., *Polysphincta lunata* Cress., *Lissonota frigida* Cress., *L. varia* Cress., *L. rufipes* Cress., *L. pleuralis* Cress., *Bathycetes scutellaris* Cress., *Meniscus elegans* Cress., *Coleocentrus pectitii* Cress., *Cryptus americanus* Cress., *C. nuncius* Say, *C. per-similis* Cress., *C. limatus* Cress., *Amblyteles caliginosus* Cress., *A. brevipennis* Cress., *A. instabilis* Cress., *A. insolens* Cress., *A. jucundus*

Brull., *A. malacus* Say, *A. comes* Cress., *A. laetus* Cress., *A. rufiventris* Brull., *A. orpheus* Cress., *A. lewissi* Cress., *A. sublatus*

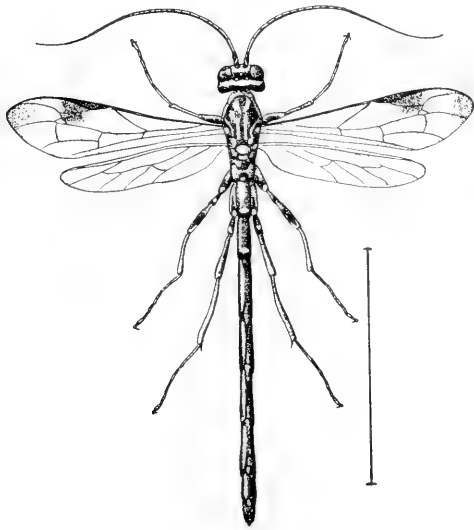


Fig. 53. *Megarhyssa lunatrix* Fab.

Cress., *A. acerbus* Cress., *A. cincticornis* Cress., *A. questuosus* Cress., *A. brevicinctor* Say, *A. amulipes* Cress., *A. ventralis* Cress., *A. suturalis* Say, *A. laetus* Brulle, *Pterocormus* sp. (see colored plate 2), *Megarhyssa atrator* F., *M. lunatrix* F., *Ichneumon canadensis* Cress., *I. irritator* F., (Fillmore Co., Sept. 15), *I. funestus* Cress., *Trogus quebecensis* Prov. The following genera also are represented in our collection: *Trioxys*, *Lysiphlebus*, *Praon*, *Plectiscus*, (Aug. 4, St. Louis

Co., woodland, along lake shore), *Porizon*, *Cremastus*, *Mesochorus* (Sept. 1, Itasca Co.), *Exetastes*, *Paniscus*, *Sagarites*, *Diodes*, *Anisitsia* (taken Aug. 28, Itasca Co.), *Neonortonia*, *Promethes costalis* Prov., has been taken at Itasca Park in Aug. and *Stoplictus marginatus* Prov. in Sept. *Periope aethiops* Cress., was found at Itasca Park the last of August, sunning on asters; *Polyblastus edalis* Cress., Itasca Park, *Hoplesmenus morulus* Say taken in Itasca Co. in Sept. The hosts of the latter are *Grapta* and *Euvanessa*.

The following have also been taken in Minnesota by H. L. Viereck in 1913: *Exochilum* sp. St. Anthony Park, Sept. *Callisphialtes* sp. Roseau Co., Aug. 20. *Paranomalon* Martin Co., Sept. 13. *Epiurus* Aug. 29 Itasca Co., flying and sunning. *Paniscus*, Sept. 15, Fillmore Co. *Iseropus*, Sept. 1, Itasca Co. *Lissonota* Sept. 15, Fillmore Co. *Aphidius* Sept. 1, Itasca Co. *Conoblasta* Aug. 28, Itasca Co. *Exolytes* Sept. 1, Itasca Co. *Stilpnus* Sept. 15, Fillmore Co. on *Cardius arvensis*. *Campoplex* Aug. 29, Itasca Co. *Phygadeuon* Aug. 16, St. Louis Co. *Cryptus* Aug. 12, St. Louis Co. woodland. *Hemiteles* Aug. 16 St. Louis Co. woodland along creek. *Anomalon* Aug. 13, St. Louis Co. woodland along lake shore. *Pezomachus* Aug. 14, St. Louis Co. woodland. *Herpestomus* Aug. 28, Itasca Park.

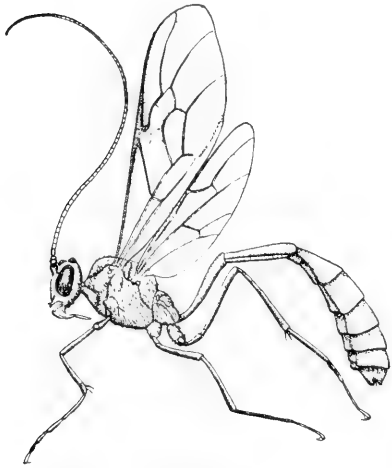


Fig. 54. (*Eremotylus*) *Allocamptus macrurus* L.

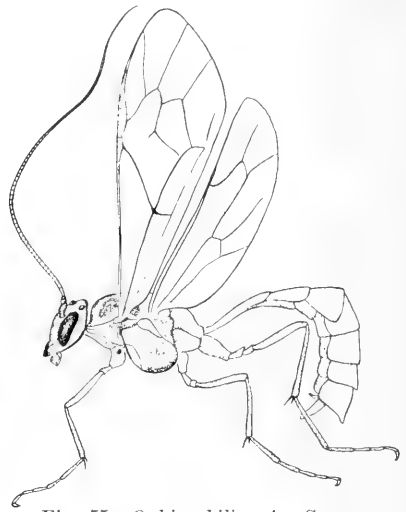


Fig. 55. *Ophion bilineatus* Say.



Fig. 56. *Pterocormus funestus* Cress.



Fig. 57. *Exetastes* sp.

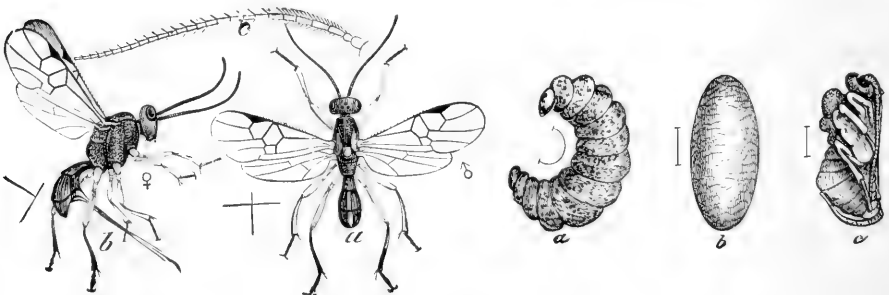


Fig. 58. *Sigalphus curculionis*, parasite on plum curculio, male and female adults, larva *a*, cocoon *b*, and pupa *c*; all much enlarged.—Report of New Jersey State Museum, 1909.

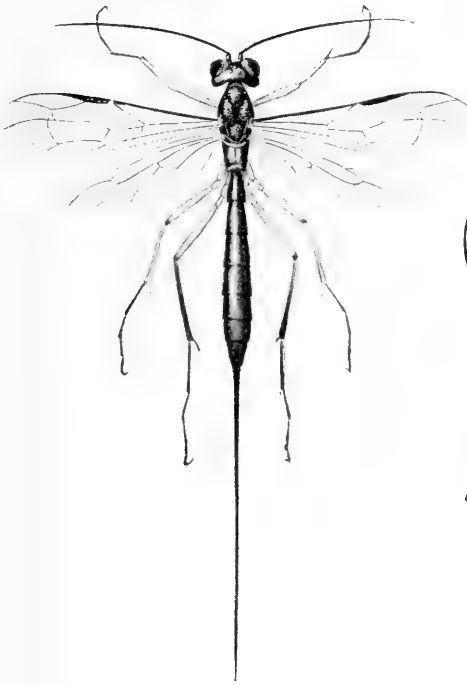


Fig. 59. *Rhyssa* sp.

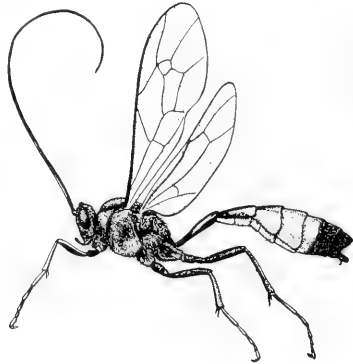


Fig. 60. *Anisitsia* sp.

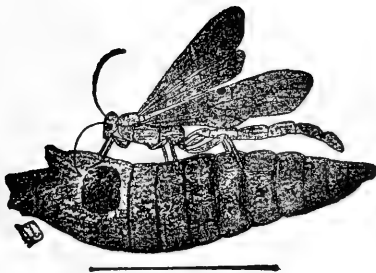


Fig. 61. *Trogus vulpinus* on a butterfly chrysalis (*Papilio*) from which it has just emerged—From Report of New Jersey State Museum 1909.

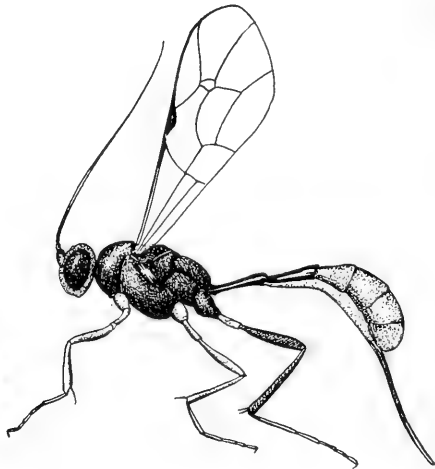


Fig. 62. *Idechthis* sp. Bred from *Ephestia kühniella*.

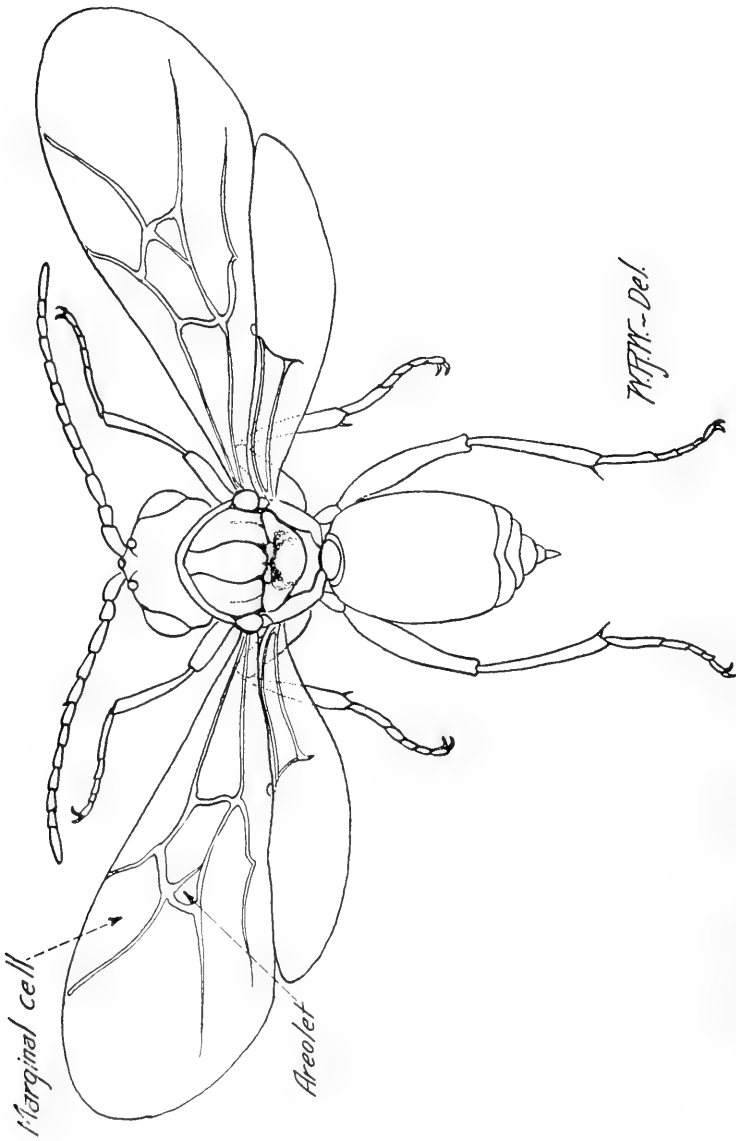


Fig. 63. *Dicotropis nebulosus*, illustrating structure and wing venation of the Cynipoidea.—From The Hymenoptera of Connecticut.

NOMENCLATURE OF WING PARTS IN THE DRAWING OF

Diastrophus nebulosus

OLD SYSTEM	COMSTOCK-NEEDHAM SYSTEM
Marginal cell	Sc ₂ + 2nd R ₁ + R ₂
Areolet	R ₄₊₅

CYNIPOIDEA

(Gall flies)

The members of this superfamily are, for the most part, typical gall makers. The peculiar growths seen upon oak and various other trees are largely the work of Cynipids; the different galls in oaks, particularly, are the work of members of this family. Some of these oak galls are designated as follows: Fibrous oak apple, spongy oak apple, larger empty oak apple, smaller empty oak apple, bullet gall, giant oak gall. On the blackberry also we have the pithy blackberry gall, and in the rose, the mossy rose gall. Lack of space forbids a detailed description of these galls.

The group may be subdivided into three divisions. (a) True gall flies, whose eggs are laid in plant tissue and whose early stages are passed within galls, Cynipidae. (b) Inquilines or guest flies; these may be referred to as tenants or dwellers in another man's property; and (c) Parasites, living in the interior of the bodies of other living insects, chiefly aphids or the larva of Diptera. This latter division is represented by the family *Figitidae*.

Guest gall flies resemble closely the true makers of the galls, and Kellogg states conjecturally that the guest species may be a degenerate, loafing scion of the working stock.

Over 200 years ago, Malpighi advanced the theory that these galls were caused by the injection of a fluid into the plant. Previous to this, it was supposed that the galls were a purely vegetable production and that the maggots found therein were due to spontaneous generation. Reamur came to the conclusion that Malpighi's views were in part erroneous and that the gall was not due to any fluid but to irritation of tissue when stung, and by the presence of the egg.

Later studies of the ecology of these insects, while still leaving much to be learned, indicate that the mere presence of the eggs or the injection of fluid by the parent do not necessarily of themselves

produce galls; but that probably gall growths are due in part at least to reactions between physiological processes of the plant tissue and the growing larva, which may absorb the sap at that particular part of the plant.

Amongst gall flies, we find the occurrence of parthenogenesis during the summer; in fact, in many species the males have never been discovered. Out of many thousand galls of *Cynips districtra* and *C. folii* (28,000 or more) about 14,000 flies were raised; but all females. The fact has been thoroly established that in many of these insects we have an alteration of generations, one of the two being parthenogenetic; individuals of one generation are like their grandparents, not their parents.

Packard says in this connection, "When we see a single oak hung with countless galls, the work of a single species, and learn how numerous are its natural enemies, it becomes evident that the demands for a great numerical increase must be met by extraordinary means like the generations of the summer broods of Plant Lice."

Referring again to the guest gall flies also found in galls, it may be said that frequently they resemble very closely the fly that makes the gall. In this connection, it may be stated that from a single species of gall, as many as 30 different kinds of insects (largely guest gall flies) have been obtained.

Gall flies appear to be closely allied to the Chalcids and resemble them strikingly. Their bodies are flea-like; trochanters usually composed of a single joint; wings usually with a characteristic venation. See Fig. 63.

FIGITIDAE

Dorsal abdominal segments extending down along the sides and meeting beneath, enclosing or concealing the ventral segments or all the ventral segments except a part of the apical one.

One species in this family is parasitic on the cabbage louse. *Pseudocoelus gilletii* Ashm. has been reared in Minnesota from puparia of *Pegomyia brassicae*. This is a most extensive family, well represented in North America. Without exception, as far as known, the species are all parasitic, principally upon larvae of Diptera, tho some prey upon aphids and one is known to attack the larva of the lace-winged fly.

CYNIPIDAE

Dorsal abdominal segments not extending down the sides (as in *Figitidae*) so as to meet beneath ventral segments. All or nearly all the ventral segments visible. Basal joint of hind tarsi usually shorter and never much longer than joints two to five united. Abdomen not at all or very little longer than head and thorax combined.

The true gall makers, affect oaks particularly. The amateur may well ask the question: "Why do galls take different shapes"; for

it is a fact that "each species of gall insect infests a special part of one or more particular species of plant, and the gall made by each species of insect is of a definite form." Cook, who has done much work on the Cynipidae believes that the morphological character of the gall depends upon the insect producing it, rather than upon the plant upon which it is produced; —for example, galls produced by insects of a particular

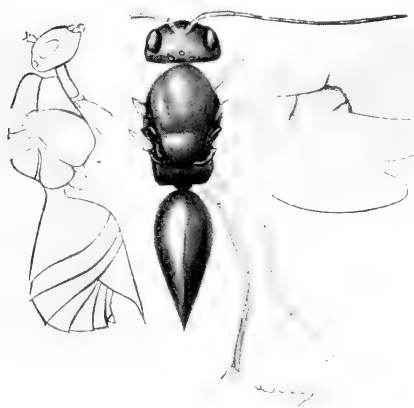


Fig. 64. (*Rhodites*) *Diplolepis rosae* L. and side view of head, thorax, and abdomen.

genus show great similarity of structure even tho on plants widely separated, while galls on a particular genus of plants produced by insects of different genera, show great differences.

The larval gall fly reaches its full development coincidentally with the full growth, or end of the vitality of the gall. On deciduous leaves, the vitality of the gall is shortest, ending in autumn; twig galls may retain their vitality all winter, or even through a second winter. The insect pupates in the dead protecting gall.

In these galls, as stated, one finds not only the gall makers, but frequently guests or parasites. Both of these groups (commensals or parasites) may themselves belong to the Cynipidae. On the other hand, the parasites may be Braconids or Chalcids or Ichneumonids, while the boarders may be beetles or lepidopterous caterpillars.

Cynips confluens Harris, is the maker of a gall known as the oak apple or may apple, found on the leaves of the red oak. These galls are sometimes two inches in diameter, green, pulpy at first, but later acquiring a hard shell with a spongy interior in the center of which is a woody kernel containing larva or pupa.

This group offers a most interesting and inviting field for the student and collector and much remains to be learned regarding it. Galls should be collected early in the autumn, separated as to kind and enclosed in muslin bags.

(*Rhodites*) *Diplolepsis rosae* L. occurs in the Lugger collection, with many other unnamed galls. We are indebted to Prof. O. W. Oestlund of the state University for the following list of Cynipid galls, collected in this state and now in the University collection.

Biorhiza forticornis Walsh, Oak Fig Gall, Cass Lake, Sept. 10. *Neuroterus batatus* Bassett, Oak Potato Gall, Manitou Junction, Oct. 15. *Dryophanta lanata* Gill, Excelsior, Oct. 1. *Holcaspis globulus* Fitch, Oak Bullet Gall, Minneapolis, Oct. 5. *Cynips confluens* Harr., Oak Apple, Burntside Lake, Aug. 17. *Amphibolips inanis* Osten Sacken, Empty Oak Gall, Duluth, Sept. 12. *Andricus petiolicola* Bassett, Oak Petiole Gall, Minneapolis. *Andricus frondosus* Bassett, Manitou Junction, Oct. 15. *Andricus seminator* Harr., Oak Seed Gall, Minneapolis. *Rhodites bicolor* Harr., Spiny Rose Gall, Minneapolis. *Rhodites multispinosus* Gill. Large Spiny Rose Gall, Cass Lake, Sept. 10. *Rhodites globulus* Beutenmüller, Globular Rose Gall, Granite Falls, Oct. 1; Cass Lake, Sept. 10.

IBALIIDAE

Same as *Cynipidae*, but basal joint of hind tarsi at least twice as long as second, third, fourth and fifth joints united. Second, third and fourth joints of tarsi longer than fifth; abdomen very distinctly compressed from side to side and distinctly longer than head and thorax united.

This family represents a small group of parasites. W. H. Harrington states that *Ibalia maculipennis* destroys the larvae of *Tremex columba* and *Xiphydria albicornis*. In the Riley collection is a single specimen of the above insect labelled "So. Ill. bred from Hickory wood June 4, 1875." Probably, therefore the group attacks, generally, members of the superfamily *Siricoidea*.

CHALCIDOIDEA

First abdominal segment not forming a scale or knot (petiole) and therefore not strongly differentiated from the remaining segments. Usually small insects, less than 3 millimeters in length and metallic.

All species in this superfamily with few exceptions (*Isosoma* for example) are parasitic. The insects are small and noted for their brilliant colors and striking forms. Dr. L. O. Howard of Washington, D. C., was the first entomologist in America to work on this group, and he and the late Mr. Ashmead applied themselves, practically

NOMENCLATURE OF WING PARTS IN THE DRAWING OF
Phasgonophora sulcata

OLD SYSTEM	COMSTOCK-NEEDHAM SYSTEM
Submarginal vein	Sc+R+M
Marginal vein	Sc ₂ +R ₁ (1st abscissa or part)
Postmarginal vein	Sc ₂ +R ₁ (2d abscissa or part)
Stigmal vein.	r (radial cross vein)

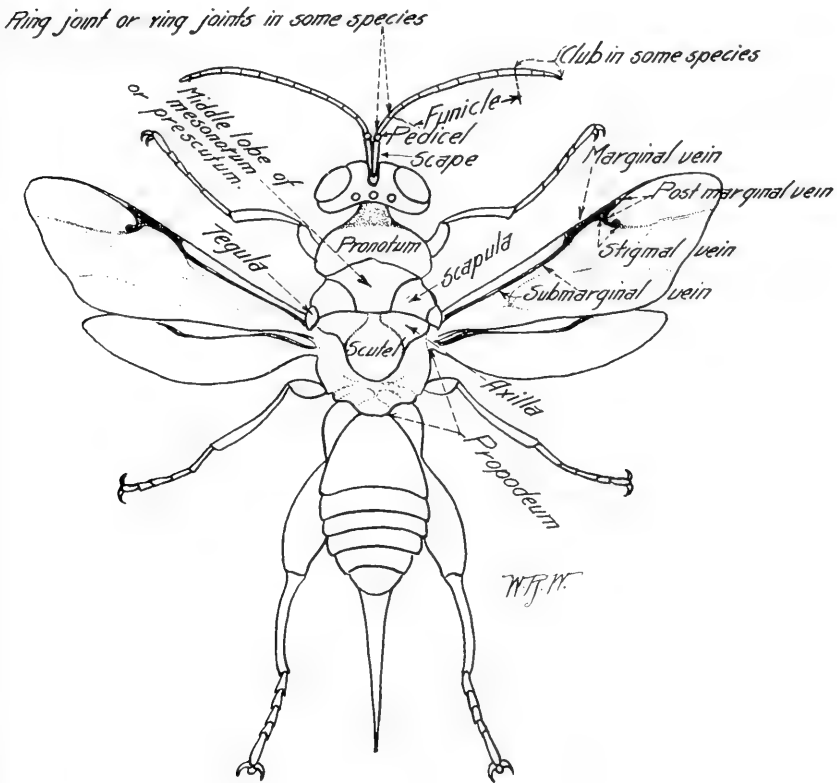


Fig. 65. *P. sulcata*, showing typical structure of a Chalcid.—From The Hymenoptera of Connecticut.

alone in the field for many years, to systematic and ecological work in this suborder. As far back as 1867, Kirchner listed 2,407 European species, and more than 4,000 species have been described. There are probably more than 1,000 species in the group in North America and a large field is still open for investigation as to species both in Europe and North and South America.

The group exhibits great variety in methods of parasitism; a large number live in galls, feeding on the gall makers themselves or guest insects frequenting the galls; others attack caterpillars; some feed only on pupae; others prey upon bees; some on scale insects and aphids,

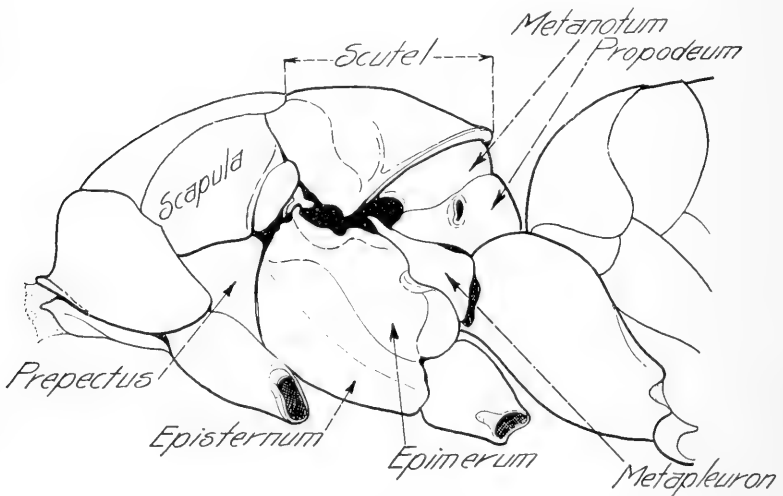


Fig. 66. Thorax of *Syntomaspis*, typical of the Chalcidoidea.—From The Hymenoptera of Connecticut.

and others are found in the egg-case of cockroaches. One European species is parasitic on the common housefly. Other species prey upon the larvae of the Hessian fly. It is evident that this group is of the greatest economic importance. Illustrative of this fact is the condition sometimes prevailing in the south, where in a certain year, 95 per cent of the eggs of the destructive cotton caterpillar were killed by a chalcid parasite.

As evidence of the work of one chalcid, we may cite the case of *Leucospis gigas*, the female of which pierces the masonry-like hardened mud walls of an European mason bee. By patient work, the

hard, stone-like wall is punctured by means of the ovipositor of this parasite and an egg introduced. Fabre has observed that one bee cell may be visited at least four times by a parasite, four eggs being deposited in a cell where there is only food supply for one larva. This, says Fabre, appears to illustrate a deficiency in instinct, for the parasite first hatched apparently destroys the eggs of its brothers and sisters.

Even a brief account of this group would not be complete without reference to the pollenization or caprification of the Smyrna Fig by a Chalcid. Caprification, as practised in Italy and the Grecian Archipelago, is a remnant of an old custom based upon the belief that figs would not develop unless so treated. It consists in making use of a chalcid, *Blastophaga grossorum* (and possibly other species), which infects wild figs. Branches of the wild fig are suspended amongst branches of cultivated varieties; the fruit on the latter is entered by the female insect and thus pollenization secured, altho she does not lay her eggs in the fruit of cultivated varieties.

This time-honored custom is probably not necessary, for figs ripen in parts of the world where this is not practised, tho Kellogg states that this process has really added the Smyrna Fig to California's fruit list.

MYMARIDAE

Hind wings linear, pedunculate at base, ovipositor usually issuing just in front of tip of abdomen. Antennae in female most frequently terminating in a distinct fusiform or egg-shaped solid club, more rarely in a two-jointed club.

Wings of members of this family are minute, slender, destitute of nerves, fringed with long delicate hairs and stalked at the base. Perhaps the most striking fact about the group is that two species are found in water, one form swimming by means of its wings.

One species is parasitic on scale insects and another has been bred from eggs of the plum curculio.

Here occurs *Alaptus excisus* West., said to be the smallest known insect. Westwood gives the following measurements: length $1/6$ mil. or $1/150$ of an inch. This, however, is probably *A. pesculus* Hal. and is about $1/2$ mil. long. Other insects may be smaller; a certain beetle for example is $1/4$ mil. long.

Halliday, in speaking of this group (Ent. Mag. Vol. I p. 342) says: "This tribe comprises the very atoms of the order Hymenoptera. Their hues are mostly black or yellowish, unadorned by metallic splendor; the plumed and iridescent wings of many are beautiful objects for the microscope. . . . The females oviposit in the eggs of other insects, from which the tiny parasite emerges only in the perfect state, a single butterfly's egg often nourishing the transformation of many individuals."

Polynema consobrinus Gir. has been bred from *Anthonomus signatus* by S. Marcovitch in our Insectary (16th Rep. State Ent. Minn. 1916) and Mr. Marcovitch has also reared *Anaphoidea conotracheli* Gir. from the eggs of the purslane sawfly. Girault reports an egg parasite of the codling moth from this family.

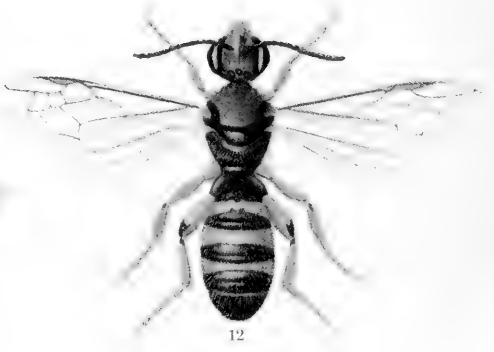
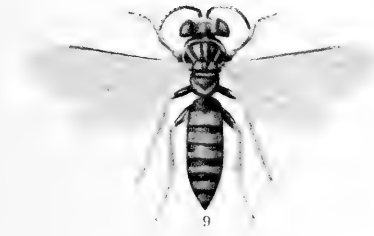
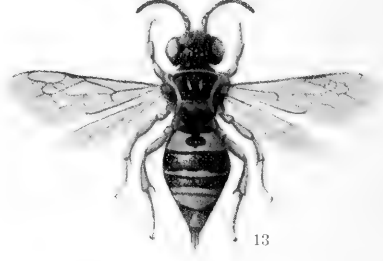
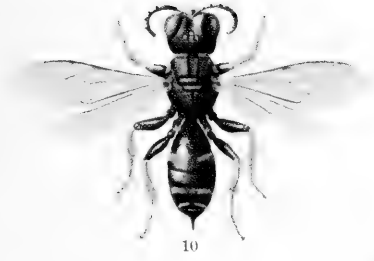
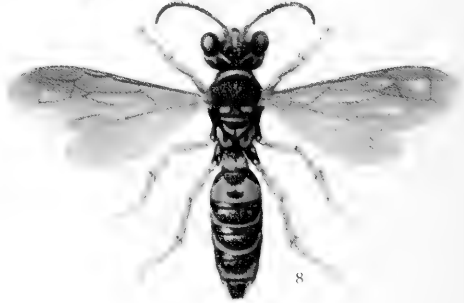
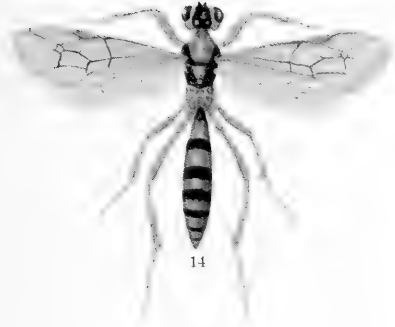
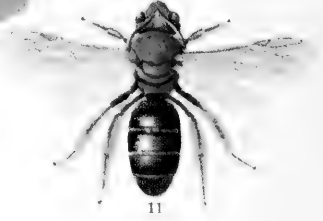
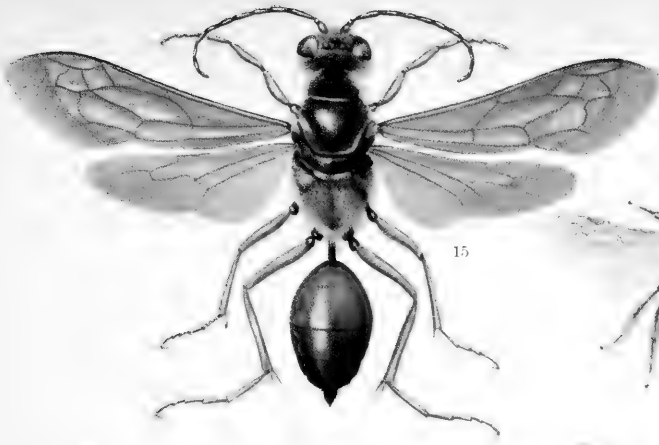
TRICHOGRAMMIDAE

Tarsi three jointed and antennae elbowed with few joints, at most 9-jointed; pubescence of wings arranged linearly.

Species have been raised from the Buffalo treehopper. Others are parasitic on the more common butterflies. In Minnesota, *Aprostoctus whitmani* Gir. has been reared from the eggs of the sunflower tortoise beetle *Physonota unipuncta* Say, and we also have in the state *Chaetostricha pretiosa* Riley.

EXPLANATION OF COLORED PLATE 2.

8. *Eucerceris zonata* Cress.
9. *Microbembex monodonta* Say.
10. *Crabro sermaenulatus*-Solenius (*Xestocrabro*) Sayi Ckll.
11. *Halictus (Agapostemon) virescens* F. female.
12. *Halictus (Agapostemon) virescens* male.
13. *Tripeolus bardus* Cress.
14. *Amblyteles (Pterocormus?) longulus* Cress.
15. *Chlorion (Ammobia) ichneumon* L.



I. L. WOOD, DEL.

DUR. ENGRAVING, M.I.

MINNESOTA HYMENOPTERA

Plate 2.

TETRASTICHIDAE

Sub-marginal vein with from one to five bristles; post-marginal vein usually absent. Scutel with four bristles, all behind the middle; abdomen sessile; hind tibiae with one spur; male antennae simple.

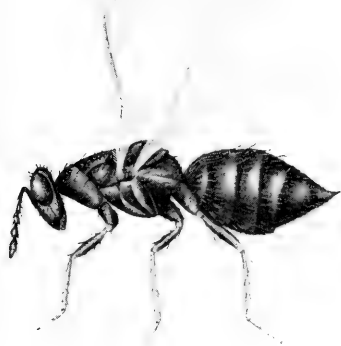


Fig. 67. *Tetrastichus* sp., bred from clover heads.

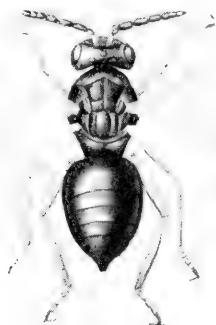


Fig. 68. *Tetrastichus* sp.

Tetrastichus esurus Riley, is a parasite of the cotton worm. Many specimens have been bred from oak galls, and the genus *Tetrastichus* is a well-known parasite of the Hessian fly. *T. racemariae* Ashm., occurs in Minnesota.

ENTEDONTIDAE

Sub-marginal vein either ornate or provided with two bristles; scutel with two bristles near the middle. Hind tibiae and male antennae as in **Tetrastichidae**.

An interesting family of parasites, its members attacking the mourning cloak butterfly, the peach lecanium, the white-marked tussock moth, and other injurious insects. The greater number of species appear to have been bred from leaf miners and particularly from the trumpet leaf miner of the apple, *Tischeria malifoliella*.

In Minnesota, Mr. Marcovitch has reared *Secodella argyresthae* Crawford from *Argyresthia alternatella*; also *Achrysocharisk ansensis* Gir. from eggs of the purslane sawfly.

EULOPHIDAE

Abdomen sessile or with a distinct petiole that is transverse and smooth. Hind coxae normal; post-marginal and stigmal veins rather long; antennae often flabellate in male.

One species in this family is parasitic on the tussock moth; others are parasitic on leaf miners and some borers; others on grain plant lice; one on the Hessian fly; and another attacks the fruit bark-beetle; another is a parasite on the woolly louse of the apple; others on oyster-shell scale and other scales including the San Jose scale.

ELASMIDAE

Abdomen as in **Eulophidae**; hind coxae very large and strongly compressed; head semi-globose, front deeply, sparsely punctate; antennae flabellate in male.

These beneficial parasites (*Elasmus*) have been reared from various leaf mining caterpillars.

Elasmus has also been bred from microgasterid cocoons and from other insects.

ELACHERTIDAE

Abdomen usually with a distinct petiole, antennae inserted below middle of face, simple in male. Sub-marginal vein entire. Hind tibiae sometimes with two spurs.

Parasites on pomace fly, horn fly, wheat plant louse, cabbage plant louse, Hessian fly, apple curculio, joint worm, cabbage butterfly, grain weevil, angoumois grain moth, strawberry weevil, etc. The eggs of one species are laid within the eggs of the tent caterpillar moth, and they have been reared by the thousands from the American tent caterpillar.

PTEROMALIDAE

Antennae elbowed, thirteen-jointed with two ring joints and three joints to the club; scape large and long; occipital line incomplete. Head most frequently transverse or subquadrate. Mandibles usually stout, three or four dentate at apex. Ovipositor issuing far anterior to tip of abdomen.

Members of this family parasitise Hessian flies, joint worms, wheat lice, cabbage plant lice and other aphids, tent and other caterpillars, strawberry weevils, cabbage butterflies, grain weevils, white

pine weevils and various other insects. They also breed in *Pimpla* and many other primary parasites.

S. Marcovitch has bred *Habrocytus obscuripes* Ashm., and *Catolaccus perdubius* Gir. in the Minnesota insectary, from the strawberry weevil. (16th Rep. State Ent. Minn. 1916).



Fig. 69. *Pteromalus puparum*.

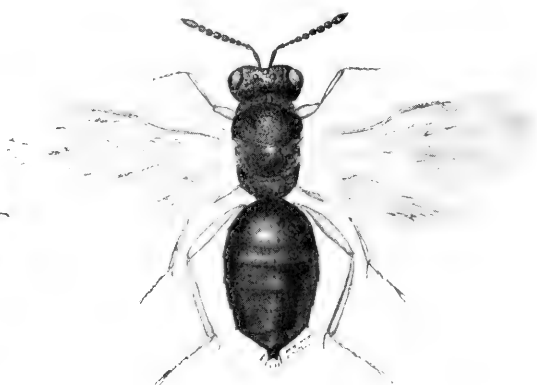


Fig. 70. *Colopisthia nematocida* Pack, parasite of larch sawfly.—From a colored drawing.

SPALANGIIDAE

Antennae 12-jointed. Abdomen distinctly petiolate. First tarsal joint not swollen.

The minute *Spalangia muscae* has been bred from *Stomoxys* pupae. The same species is known to attack the pupae of both the horn fly and the house fly. Parasitism by this species always takes place in the pupal stage of the host. In a collection of *Stomoxys* pupae made in Texas, it was found that 40 per cent were parasitized by this insect. *S. hirta* Haliday, confined with horn fly pupae promptly attacked the latter.

S. lanaiensis Ashm. has been reared from dipterous pupae. The latter two species are evidently important enemies of the horn fly.

TRIDYMIDAE

Abdomen almost sessile. Antennae 12-jointed; pronotum scarcely visible in the middle; funicle of antennae 5-jointed.

Hemadas nubilipennis Ashm. has been reared from galls on huckleberry made by *Solenozopheria vaccinii* Ashm.

APHELINIDAE

Antennae 8-jointed; notauli distinct; middle tibial spur moderately long; mesosternal pleurae distinct.

This large and useful family of parasites attacks many of the scale insects, among others, the San Jose scale, the Lecaniums, the cottony maple scale, the woolly aphid of the apple, cabbage aphid, and many other injurious forms.

Aphelinus fuscipennis How., and *A. mytilaspides* both attack the San Jose scale in California, the first named being quite abundant.

ENCYRTIDAE

Antennae 11-jointed, elbowed, scape large and rather long; pronotum small, frequently not visible in the middle. Second pair of legs long, saltatorial with a very long tibial spur. Hind wings never narrow, nor linear; ovipositor issuing far anterior to tip of abdomen.

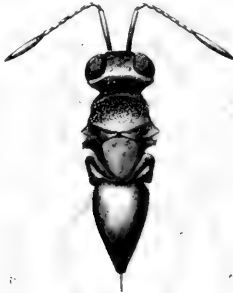


Fig. 71. *Copidosoma gelechiae* Howard. Reared from gall on golden rod.

Parasitic on oyster-shell scale, rose scale, maple scale, joint worm, Hessian fly, ladybird beetles. Bred from puparia of syrphid flies; found in caterpillars of various moths and butterflies. Species have been bred from cabbage lice, from bag worms, and are found in the egg sacks of spiders. They are also

parasitic on eggs of certain species of butterflies, and on mealy bugs. (Timberlake Univ. of Calif. Bull. March 28, 1918.)

Aphycus pulvinariae How. is a parasite of the maple scale and *A. brunceus* How., a parasite of the rose scale. *A. flavus* attacks the European fruit Lecanium in California. *Chiloneurus dactylopii* How. and *Encyrtus inquisitor* How. probably occur in all greenhouses where their host, *Pseudococcus citri*, is found. *Encyrtus (Aphidencyrtus) aphidiphagus* Ashm. attacks the cabbage aphid. *Copidosoma gelechiae* How. occurs in Minnesota, its host being *Grossimoschema gallae-solidaginis*.

SIGNIPHORIDAE

Antennae 6-jointed; marginal vein about as long as subcostal vein. Second pair of legs long, saltatorial with a very long tibial spur. Pronotum small, frequently not visible in the middle.

Signiphora flavopalliata Ashm. is parasitic on *Lepidosaphes beckii*; and *S. occidentalis* How. has been reared from the red scale.

EUPELMIDAE

Pronotum small, frequently not visible in the middle. Second pair of legs as in the two preceding families. Antennae 13-jointed; occipital margin of vertex rounded.

Eupelmus allynii French is an important parasite of *Mayetiola destructor*; *E. reduvii* How. has for its host the common squash bug. *Eupelmus coleopterophagus* Gir. has been reared, in Minnesota, from the strawberry weevil by S. Marcovitch (16th Rep. State Ent. Minn. 1916). The female of *Eupelmus mirabilis*, a species bred by C. V. Riley from the eggs of the angular-winged katydid, and from the eggs of a large sphinx moth, is able to roll itself up into a more or less compact ball. See Riley's excellent illustration, Fig. 48, p. 162, 6th Mo. Report where he refers to the species under the name of *Antigaster mirabilis*, as "The back-rolling wonder."

CALLIMOMIDAE

Thorax not strongly developed, pronotum large; antennae many jointed, elbowed; body metallic, sides of scutellum curved, abdomen frequently compressed; if without an extended ovipositor, the abdomen is conical or conic-ovate; ovipositor far anterior to tip of abdomen. Fore tibiae armed with a large curved spur.

Specimens of the Genus *Ornyrus* have been bred from cynipid galls and from *Rhodites*. *Diomorus zabriskei* Cress. is parasitic in nests of *Ceratina dupla*. *Oligosthenus stigma* F. has been reared from *Rhodites rosae* and *Syntemaspis druparum* Boh. from apple seeds. *Megastigmus nigrovariegastus* Ashm. has been bred from seeds of *Rosa rugosa*.

EURYTOMIDAE

Mandibles not strong, mostly 4-dentate at apex. Thorax as in preceding family. Antennae many jointed, with ring joints, rarely without; scape large and rather long; body not metallic; sides of scutellum almost straight; anterior tibial spur large and strong, middle tibial spur small and weak, hind tibiae with two apical spurs. Ovipositor far in advance of tip of the abdomen.

Members of this family are markedly parasitic. Species have been reared from the eggs of tree cricket, from the fruit bark beetle, and many other forms. There are, however, in the group, a few species

which are not parasites. *Brucophagus funebris*, for example, is the well-known clover-seed chalcid, very destructive to seed of clover and alfalfa; and of the genus *Isosoma*, *I. tritici* and *I. hordei* called "joint worms," live in grain or grasses. Here occur both winged and wing-

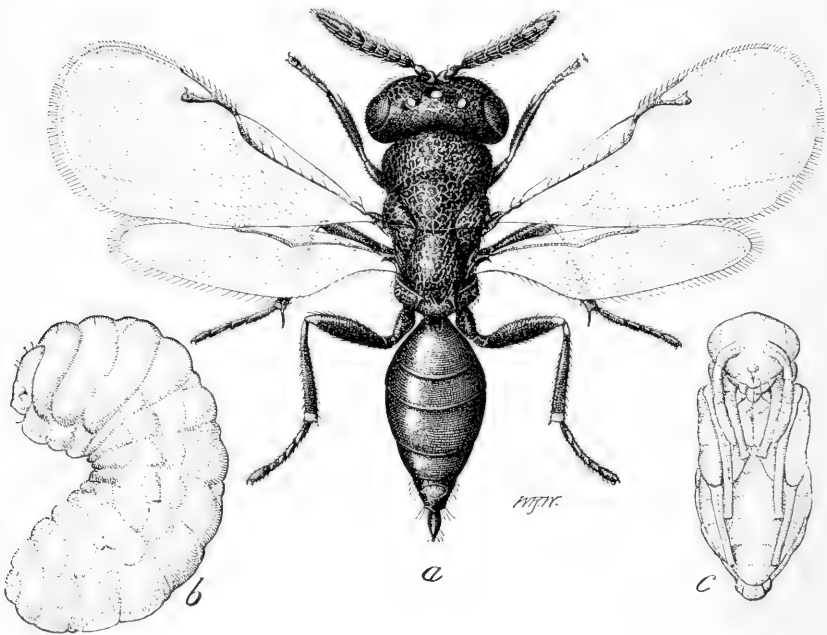


Fig. 72. The clover seed Chalcid, *Brucophagus funebris* after Urbahns, U. S. Bureau Ent. a imago, b larva, c pupa.

less females. These insects produce galls on wheat stems, checking the growth of the plant and causing the leaves to yellow. One or more gall-like swellings of the stem of grains or grasses denote the presence of the larva. Straw should be used up completely during the winter, for the adult insects emerge from infested stems in the spring.

I. tritici and *I. grande* were supposed to be two distinct species, but it has been demonstrated by Riley that there is here, really, an alternation of generations of one species. Both generations may be wholly or in part parthenogenetic. *Eurytoma pissodis*, described by Girault in Bull. Brooklyn Ent. Soc. is parasitic on the white pine weevil.

Macrorileya occanthi Ashm. has been reared from the eggs of the snowy tree cricket. *Eurytoma crassineura* Ashm. is parasitic on Scolytids. *Evoxytoma vitis* Saunders, has been reared from grape seeds. *Eurytoma gigantea* Walsh has been reared in Minnesota by S. Marcovitch from goldenrod gall. *E. juniperinus* Marcovitch was reared from deformed berries of *Juniperus virginiana* L. Oct. 13. (Ann.

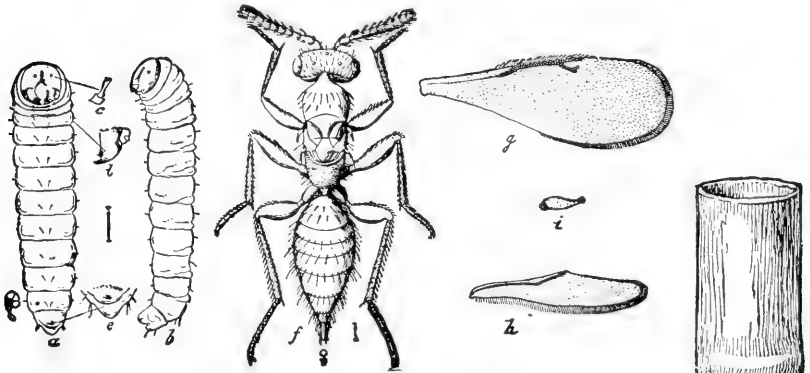


Fig. 73. *Isosoma tritici*, a, b larva, f female, g fore wing h, hind wing.—The Insects of New Jersey, 1909.

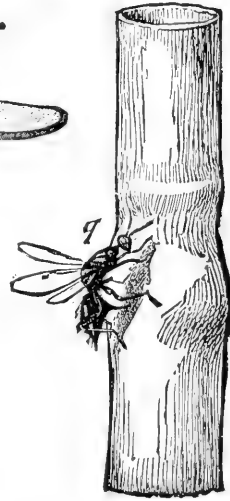


Fig. 74. Female *Isosoma* ovipositing in stem of wheat.—Insects of New Jersey, 1909.

Am. Ent. Soc. 8 pp. 166-168). *Bruchophagus funebris* How. the clover seed chalcis is common in Minnesota, destroying the seeds of crimson clover and alfalfa.

PERILAMPIDAE

Antennae elbowed, fore tibiae armed with a large curved spur; hind femora not greatly enlarged; thorax strongly developed, much arched and deeply punctate; stigmal vein developed; abdominal segments visible.

Perilampus hyalinus Say occurs in Minnesota (see colored plate 1). Reported as parasitic on the pine saw fly. It is also a secondary parasite on *Amelectonus fugitivus* Say. Ashmead has reared *Perilampus* sp. from *Chrysopea* cocoons.

EUCHARIDAE

Same as *Perilampidae*, but stigmal vein not developed, and second abdominal segment very large, inclosing other segments. Ovipositor well forward.



Fig. 75. *Pseudomctegia* sp. dorsal and side view.

In members of this family, the structure of the thorax, particularly of the scutellum, is most curiously modified. This modification with the brilliant metallic blue and green coloring which characterizes the members of the family, make it perhaps the most striking group of the superfamily. Some, or all, attack ants and

are particularly abundant in tropical countries where ants abound. Fig. 75 illustrates a species found in Minnesota.

CHALCIDIDAE

Antennae elbowed and with one, two or three ring joints, very rarely without ring joints; tarsi 4 or 5-jointed, fore tibiae armed with a large curved spur, hind tibiae with two apical spurs; hind femora much swollen; fore wings never folded; ovipositor rarely prominent, not curved over dorsum of abdomen. Abdomen most frequently conical or conic ovate, more rarely globose or oblong.

Strongly typical of the suborder and containing a large number of useful parasites. At least one species is a secondary parasite on parasites working on Lepidoptera larvae.



Fig. 76. *Phasgonophora sulcata* Westw.

The minute and interesting chalcid *Podagrion* (Palmon) *pachymenes* is said to shelter itself under the wings of a species of Mantis

in order to be in favorable position to oviposit in the eggs of the latter when it is forming its peculiar egg case or ootheca.

Spilochalcis mariae Riley parasitizes our larger moths, *Telea*, *Samia* etc. *S. debilis* Say is a secondary parasite of *Hemerocampa leucostigma*; its hosts are *Amorphota orgyiae*, *Meteorus communis*, *M. hyphantiae*, *Protapanteles hyphantrae*, *P. delicatus*. *Chalcis compsilurae* Crawf., has been reared from puparia of *Compsilura concinnata*.

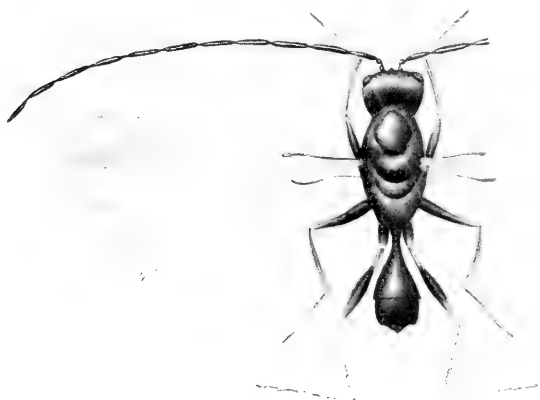


Fig. 77. *Polynema striaticorne* Gir.

Minnesota species: *Phasgonophora sulcata* Westw., *Polynema striaticorne* Gir. *Spilochalcis* sp.

LEUCOSPIDAE

As in **Chalcididae**, but fore wings when at rest folded longitudinally, and ovipositor is curved over dorsum of abdomen.

In Minnesota *Leucospis affinis* Say has been bred from the nests of a leaf-cutting bee.

NOMENCLATURE OF WING PARTS IN THE DRAWING OF

Serphus caudatus

OLD SYSTEM	COMSTOCK-NEEDHAM SYSTEM
Veins	Veins
Basal	M and <i>m-cu</i>
Cubital	Media and at wing margin $R_{4+5}+M_1$
Transverse Cubital	R_3 and <i>r-m</i>
Recurrent	M_{3+4}
Cells	Cells
First submarginal	1st R_1+R
Fused cells beyond 1st submarginal	R_{3+4+5}
Marginal (reduced to a minute area beyond the stigma)	2d R_1+R_2

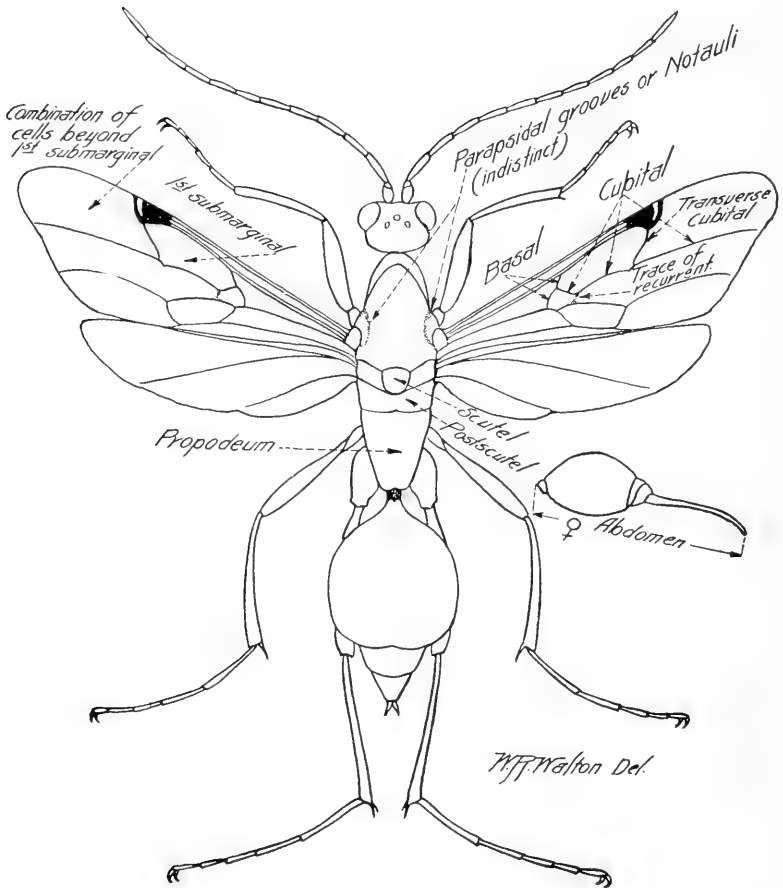


Fig. 78. *Serphus caudatus*, structure typical of the Serphoids.—From the Hymenoptera of Conn.

SERPHOIDEA

(Proctotrypoidea)

Abdominal segments not strongly differentiated as petiole and gaster; wings usually well developed, sometimes vestigial or lost; body not flea-like; wings usually without veins, or with only sub-costa and part of radius present. Slender insects, mostly small.

Many of these are egg parasites transforming within the eggs of their victims, largely butterflies, moths and Hemiptera. Species very minute, hardly to be seen with the naked eye, extremely active and of brown or black coloration. They may be obtained by sweeping, with a net, grass and other herbage. Some of the species lay their eggs in the larvae of various wheat flies. The larva of one genus (*Gonatopes*) has been found fastened under the wings of leaf hoppers. Some species have been reared from larvae or galls of small Dipterous midges, some from cynipid galls, some from ants' nests, and some are known to attack Coleoptera.

PLATYGASTRIDAE

Trochanters with two joints, or stigma very short and broad; antennae inserted below middle of face at junction of clypeus with face; wings wanting in most species; abdomen with sides acute or margined; labial palpi with one joint; abdomen sessile or sub-sessile.

One species of this family oviposits in the eggs of the spring canker worm and helps to keep it in check. Another is an egg parasite of the Hessian fly, and it is claimed that from a single egg of the parasite, there may develop several of the adult insects. Members of the family exhibit a wide choice of victims. Species are known to attack a Cecidomyid, feeding on walnut, a blackberry gall midge, a nut weevil, the Carolina locust and other locustids, the squash bug, tree crickets, the harlequin

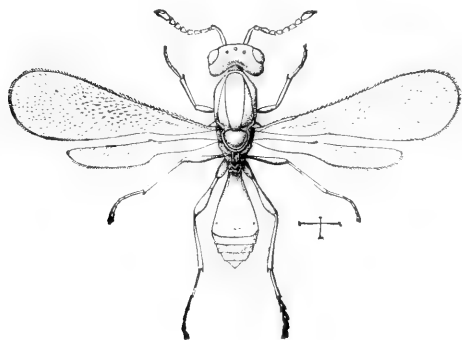


Fig. 79. *Platygaster herrickii*.—From Proc. U. S. Nat. Mus. Vol. 8, pl. 23.

cabbage bug, the fall web worm, tent and other caterpillars, the tussock moth, tabanids, clover flower midge. *Leptacis* sp. taken by H. L. V. in Fillmore County, September 15.

SCELIONIDAE

As in the preceding family, but labial palp has two or more joints. Antennae with twelve, eleven or seven joints. Abdomen generally carinated.

Parasitic on locusts, tree crickets and various bugs and caterpillars. Specimens have been bred from the corn worm, from the eggs of the tussock moth and eggs of Diptera.

Scelio luggeri (Riley) Ashm. occurs in Minnesota, parasitic on the eggs of *Caloptenus*. The genus *Telenomus* also occurs in the state and doubtless many forms not evidenced in our collection.

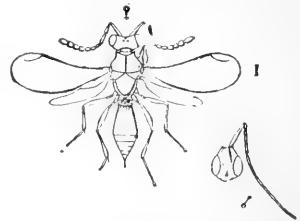


Fig. 80. *Telenomus* sp.

CERAPHRONIDAE

Trochanters with two joints, or stigma very short and broad; antennae inserted below middle of face; abdomen with sides rounded.

A Hessian fly parasite, *Ceraphron destructor*, occurs in this family; also a parasite on the cherry aphid. *Lygocerus niger* How. is parasitic on grain plant lice; *Eumegaspilus erythrothorax* Ashm. is found in nests of *Lasius*. *Measpilus striatipes* Ashm. has been bred from a *Pegomyia* puparium in our Insectary.



2 CERAPHRON JUREK
Fig. 81. *Ceraphron humatatus*—
U. S. Nat. Mus. Bull. 45.

DIAPRIIDAE

Wings present, sometimes absent; front wings never with a more or less distinct stigma; hind wings with no basal cell; labial palpi with two joints; antennae 12-13- or 14-jointed, inserted on the middle of the face, usually on a frontal prominence; trochanters 2-jointed, or stigma very short and broad.

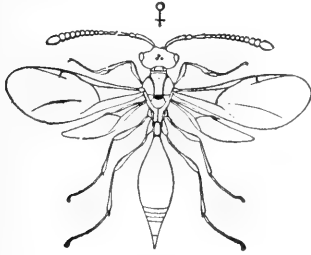
Bred from syrphus flies, wheat stem maggot, cabbage maggot and other Diptera.

Entomacis ambigua Brues, is found in nests of *Stemamma fulvum-piceum*. *Loxotropa pegomyae* Brues has been bred from the cabbage maggot in Minnesota. *Galesus* sp. taken by H. L. V. at Itasca Park Sept. 1. *Diapria* (*Tropidopria*) *conica* F. is a parasite of *Eristalis tenax*. For an account of the biology of this species see G. E. Sanders Can. Ent. 43 (48-50) 1911.

BELYTIDAE

As in *Diapriidae*, but labial palpi with three joints.

"An extensive and but slightly studied group closely related to the *Diapriinae* and formerly confused with them. . . . Nothing is known of the habits of the species comprising this group, altho Nees von Esenbeck and others believe they undergo their transformation within the larvae of *Diptera* that inhabit fungi. From their close structural resemblance to the *Protoctrypinae*, this supposition is probably correct." Ashmead on *Belytinae*—Bull. U. S. Nat. Mus. No. 45, p. 345, 1893.



♂ ACROPIESTA-♀

Fig. 82. *Acropiesta flavicauda*.
U. S. Nat. Mus. Bull. 45.

Belyta fulva Cameron, is recorded from *Bolitophila luminosa*.

SERPHIDAE

Trochanters with two joints or stigma very short and broad. Antennae inserted on middle of face; wings present; wings may be absent; front wings when present with a more or less distinct stigma; mandibles without teeth; antennae with thirteen joints.

Serphus obsoletus Say is parasitic on *Stelidota stugosa*, having been reared from the latter insect by Professor Comstock.

S. caudatus Say is widely distributed over the U. S. and probably occurs in this state.

S. clypeatus has been reared from a tree fungus from which *Melandryid*, *Mycetophagid*, *Staphylinid* and *Scaphidiid* beetles were obtained.

An unidentified *Serphus* was taken at Itasca Park, Sept. 1, by H. L. V.

HELORIDAE

Similar to *Serphidae*, but mandibles with teeth, and antennae with fourteen or fifteen joints.

Members of the family are parasites, typical of the group.



Fig. 83. *Helorus paradoxus* Prov.,
female.

“So far only a single species (of Helorinae) has been detected in our fauna.” Ashmead, p. 331, Proc. U. S. Nat. Mus. 45, 1893. *Helorus paradoxus* Prov. is parasitic on the cocoon of *Chrysopa*. It occurs in Minnesota. The genus *Helorus* is represented in Europe by several species.

PELECINIDAE

Trochanters with one joint; antennae with fourteen joints; mandibles without teeth; stigma very narrow, long; antennae inserted on middle of face; abdomen of female greatly lengthened, about five times the length of head and thorax united, composed of six segments; male abdomen clavate.

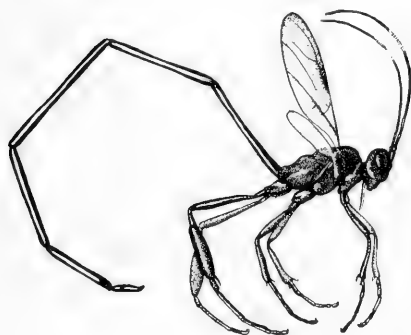


Fig. 84. *Pelecinus polyturator* Drury, female.

The male in this family differs strikingly from the female in the fact that the abdomen of the former is not elongated.

Pelecinus polyturator Drury, occurring in Minnesota, is a striking species, the female having a long slender abdomen in marked contrast to the short abdomen of the male. The latter is rarely seen. The species is parasitic on grubs of the May beetle (*Lachnosterna*), and is common over most of the temperate parts of the New World.

FORMICOIDEA

A deep constriction at the base of the first abdominal segment conspicuously separating the abdomen from the thorax; the first abdominal segment forming a scale or knot (petiole).

All true ants occur in this super-family and in the single family which alone represents the group.

True ants are at once recognized by the presence of one or two knots or scales at the base of the abdomen.

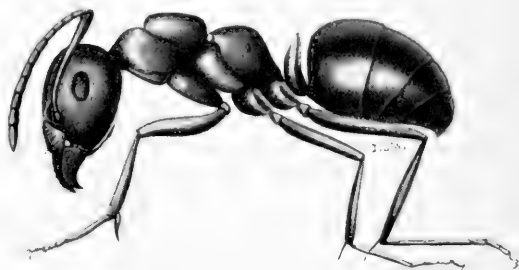


Fig. 85. *Formica sanguinea* Latr.

More than 2,000 species have been described, and it is estimated that there are probably 5,000 species in existence. Distinctively social insects for the most part, each colony is characterized by the presence of one or more queens, living in harmony (in this respect differing from social bees). There are also in each colony, worker ants which may be represented by more than one class, and in some species we find soldiers whose duty it is to fight for the colony they represent. The workers are sterile or undeveloped females. The soldiers are workers with large heads and powerful jaws. Their functions are those of



Fig. 86. *Formica fusca* L., female.

guarding the nest, fighting, crushing seeds, etc. Both male and female ants in most species are winged at time of mating, and it is no unusual thing in summer to see swarms filling the air during their nuptial flight. After this is accomplished, the females strip off their wings and proceed to egg-laying. There are, however, certain species in which wings are never developed. Where one or both of the sexes are wingless, mating must take place on or in the ground. The eggs of ants are white or yellowish and hatch in about fifteen days, tho at least one observer (Lubbock) claims a longer time is required, from 30 days to six weeks. The pupal stage lasts from three to four weeks. The pupae are carried about by the workers to different places in the nest as occasion may require, and if one disturbs an ant nest in sum-

mer, the occupants will be seen running excitedly about, carrying the yellowish pupae in their jaws. These pupae are popularly supposed to be the eggs.

Historically, ants are more prominent than any other insect, their industry is often cited, and the habits of ants, in colony life, have been made the object of profound study. Scholars have marveled at their seeming intelligence evidenced by a "language" (an apparent communication by means of their antennae), by their care of aphids from which they obtain a pleasing nectar, by their enslaving ants of other colonies, by their storing vegetable tissue in their nests, which later forms an



Fig. 87. *Lasius* sp. female.

excellent culture for the growth of a fungus used by the ants as food. Recognition of friends even after separation, is effected, as above indicated, by antennal touch; and an ant in distress causes solicitude amongst the others. On the other hand, they are equally quick in recognizing enemies, or ants from another colony, and such recognition means a battle royal.

Further examples of what was regarded by early observers as intelligence on the part of ants are not lacking; mud "sheds" are sometimes built by them over colonies of aphids, feeding in the open air, thus protecting these insects from which they obtain nectar; the ant genus *Lasius* carries plant lice to suitable plants where an abundance of food is assured, and it is claimed, in the autumn, takes the eggs of aphids into its burrow for protection against winter cold.

In spite of the early beliefs that the complex actions of ants must be accounted for on the ground that these insects possess intelligence, modern scientists have denied the possession of psychic faculties on the part of ants or other insects. Bethe has made a careful study of the ecology of this group as a result of which he states "they learn nothing, but act mechanically in everything they do, their complicated reflexes being set off by simple physiological stimuli."

Some ants make sounds by tapping or scraping leaves with their heads (by inference, therefore, ants can hear).

The bite of some species, as many of us are aware, is painful. They are extremely courageous, battling fiercely with hostile colonies. Their relative strength is out of all proportion to the size of the insects; we

frequently see ants dragging dead caterpillars or grasshoppers many times their size and weight.

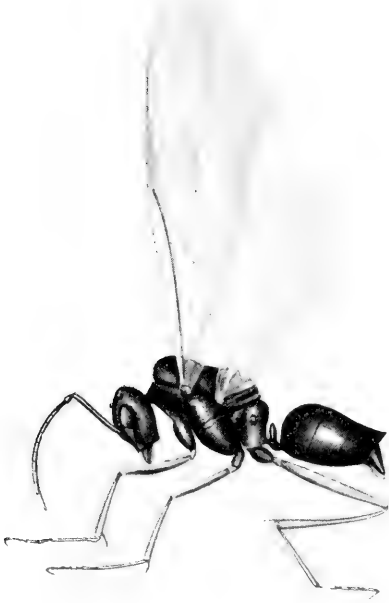


Fig. 88. *Lasius* sp. male.

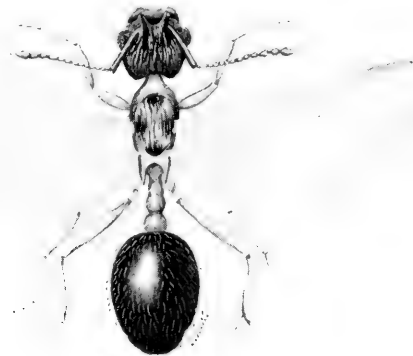


Fig. 89. *Myrmica* sp. female.

For an exhaustive account of ants, the student is referred to that excellent work of W. M. Wheeler, "Ants, Their Structure, Development and Behavior"—Columbia University Press, 1910.

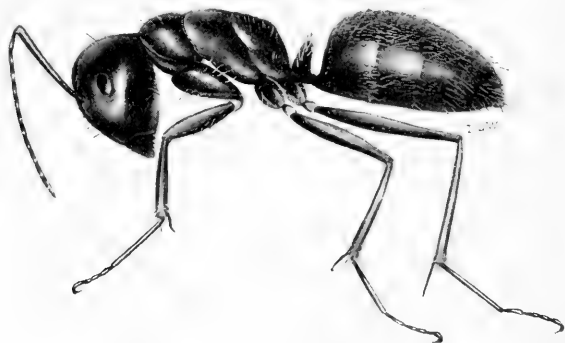


Fig. 90. *Camponotus herculeanus* L. sub species *pennsylvanicus* De Geer.

FORMICIDAE

With the characteristics of the sub-order

In this, the only family of the suborder, we find familiar and interesting species, as well as exotic forms exhibiting most wonderful traits.

Lasius niger, var. *americanus* is the little ant of our lawns and walks. It is sometimes called the "corn louse ant" because it acts as nurse for the corn root louse, *Aphis maidiradicis*. Packard says of this species "The little yellow ant, abundant in parks and about houses in New England generally swarm on the afternoon of some hot day in the first week in September, when the air is filled toward sunset with myriads of them. The females after their marriage flight in the air may then be seen entering the ground to lay their eggs for new colonies."

An account of the relations of ants to aphids or plant lice might easily be sufficient to fill a good sized volume. The basis of this amicable association lies in the fact that the sweet nectar elaborated from sap by aphids is very attractive to ants, and they frequently resort to tapping the plant lice with their antennae to induce them to give up the liquid. This caress or tapping frequently results in a louse emitting, not through the honey-tubes as originally supposed, but through the anal opening, a drop or two of this fluid, which is eagerly eaten by the ant. This process is sometimes alluded to as "milking the aphids," and

plant lice have been called "ants' cows." Because the ants in many cases act as nurses for plant lice, protecting them from harm in various ways, and encouraging their increase, they are indirectly injurious to the farmer, orchardist, and gardener. An orchardist who sees large numbers of ants on his trees, must not infer that they are themselves working injury to the tree. A careful search will doubtless disclose large numbers of plant lice.

Ants are also associated with insects other than aphids. One finds in their burrows ants' nest beetles (*Pselaphidae* and other families) also Hemiptera and Orthoptera. A few crustaceans also live with ants. Some of these aliens in ants' nests are parasites, some are messmates. Of 1,177 species of insects recorded by Wasmann in 1900 as living for a part or all of their time in ant nests, 993 were beetles (*Pselaphidae*, *Staphylinidae*, *Histeridae*, *Silphidae*, etc.), 76 were Hemiptera (plant lice and scale insects), 39 Hymenoptera, 26 Lepidoptera larvae, 20 Thysanura, 18 Diptera, 7 Orthoptera larvae, 34 mites and 20 spiders.

Monomorium pharaonis is the tiny house ant introduced into this country from the Old World, barely visible, yet sometimes a great pest. To be successful in eradicating it from a house, it is necessary to destroy not only the workers of the colony but the queen or queens. This is sometimes accomplished by means of fumigation. So tiny are these insects that it requires "17,000 individuals to weigh one gram." (Cambridge Natural History.)

All of our native ants, with the possible exception of the house ant just mentioned, live in galleries and chambers in the ground. It is said that some species dig as deep as nine feet. The underground excavations are generally accompanied by hills of various sizes on the surface.

Conditions under which ants are troublesome are so varied that individual cases should be referred to Experiment Station authorities.

The family is well represented in Minnesota *Camponotus*, *Lasius*, *Formica*, *Myrmica* and *Aphaenogaster*.

CHRYSIDOIDEA

Abdominal segments not strongly differentiated as petiole and gaster; tegulae present, wings usually well developed, sometimes vestigial or lost; hairs of dorsulum simple, not branched or plumose; abdomen with three segments visible, segments beyond third hidden.

These are the most brilliantly colored of the wasps. Some may be iniquilines or "guests," though Ashmead believed they are all para-

sites (Psyche, May 1894). Walsh has bred *Chrysis caerulans* from the potter wasp. The species are small, but conspicuous on account of their brilliant coloration, generally metallic green or blue. They run or fly rapidly in the hot sunshine and in England have been given the name of "cuckoo flies," because of their resemblance in habits to the European cuckoo, in that they steal into the nests of fossorial wasps or bees, as the cuckoo does with other birds, when the owner is away, and lay eggs therein. They are most persistent parasites and an incident is on record where an enraged wasp returning to her nest and finding a "cuckoo fly" on the point of leaving her egg there, attacked the latter, and being unable to sting her because Chrysidids double themselves up and present only an armoured surface, gnawed off the parasite's wings and threw her out on the ground. The unwelcome and disabled parasite however, after the departure of the rightful owner, crawled up the post and into the nest wounded as she was, and deposited her egg before dying.

CHRYSIDIDAE

With the characteristics of the sub-order

The insects of this family are often called "cuckoo flies" or "gold wasps."

The only family in the suborder and hence partakes of all the characteristics given above. The species are well distributed over most parts of the world. While a few forms attain a length of $\frac{1}{2}$ inch or more, they are for the most part small insects. Their bodies are strikingly stout. The abdomen of some species is tipped with red. The sting has no poison sack and is at the end of a retractile tube consisting of the posterior abdominal segments. There are over 400 known species which are guests or parasites in the nests of bees and wasps.

Chrysilauta, *C. (Tetrachrysis) caerulans* F. (see colored plate 1). *C. (Tetrachrysis) nitidula* F. *C. (Oleoehrysis) pacifica* Say, and *Hedychrum* sp. occur in Minnesota. *Tetrachrysis* sp. taken in Martin County on Aster in September.

VESPOIDEA

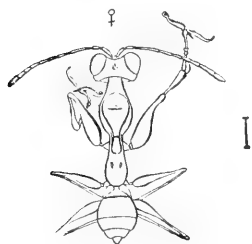
Wings usually well developed, sometimes vestigial or lost; body not flea-like; wings usually with venation well developed; trochanters composed of one joint; cutting edge of mandibles turned inward, their tips meeting or overlapping when mandibles are flexed toward mouth.

This familiar group contains, besides some parasites, our social wasps, strictly predaceous and insectivorous. They feed their young

with chewed insects for from 8 to 15 days, or to the end of their larval life. They do not store up food, and colonies persist for only one season. In the more common species, nests consist of comb and enveloping layers made of a papery material secured by scraping wood fiber from weather worn boards and posts and mixing it with a salivary secretion. They will take paper itself when sufficiently wet and pulpy. Here occur our "yellow jackets" and "hornets." These particular insects are fond of meat and are attracted to exposed beef carcasses in butcher shops and elsewhere.

BETHYLIDAE

Wings not folded longitudinally in repose; wings may be absent or reduced; no constriction between first and second abdominal segments; discoidal cells obsolete, or, if the first is present, it is petiolate; head oblong; antennae with twelve or more joints; fore tarsi of female never chelate.



♀ G. FLAVIFRONS

Fig. 91. *Gonatropus flavifrons*.—U. S. Nat. Mus. Bull. 45.

For an interesting account of the life history of a Bethylid, see Howard's "Insect Book" p. 34, where Mr. Busck's observations upon *Laelius trojodermtis* Ashm., parasitic on Dermestid larvae, are published at some length.

Pseudisobrachium myrmecophilum Ashm. lives in ant nests, as does also *P. mandibulare* Ashm. *Neoscleroderma tarsalis* Ashm. is parasitic on *Silvanus surinamensis*. Other forms are parasitic in various beetles. *Goniozus* sp. is parasitic on the codling moth.

DRYINIDAE

As in *Bethylidae*, but the head is transverse, subquadrate or globose; antennae 10-jointed; stigma large; fore tarsi of female chelate.

Dryinus ormenidis Ashm. is parasitic on *Ormenis pruinosa* and *O. septentrionalis*, and the latter insect is also parasitized by *Gonatopus typhlocybae* Ashm.

SCOLIIDAE

Females winged. Wings not folded longitudinally in repose; a constriction between the first and second abdominal segments; legs of usual length; posterior femora when directed backward not reaching to middle of abdomen; sternellum large, sharply defined, extending between intermediate coxae; tibiae usually flattened with bristles exteriorly.

These are large powerful Hymenoptera, usually hairy, black, generally with bands or spots of red and yellow. Some of the species prey upon the larvae of lamellicorn beetles, the female Scoliid penetrating the ground to find the larvae. *Tiphia inornata*, shiny, black, is parasitic on white grubs. Numerous wingless forms occur in the family, the larvae living parasitically at the expense of other Hymenoptera.

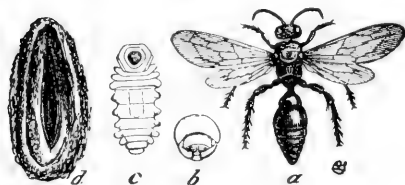


Fig. 92. *Tiphia inornata*, a white grub parasite; a. adult; b. head of larva; c. larva; d. cocoon.—From Insects of New Jersey, 1909.

In the genus *Elis*, the females are much more robust than the males and have short antennae,

while the males are long with slender antennae, and the radial cell, unlike that in the female, touches the costal margin of the wing. This genus is quite commonly seen on the flowers of golden rod and on flowers of umbellifers. *Elis quinquemaculata* Fab. and *Campsomeris plumipes* Drury, occur in this state.

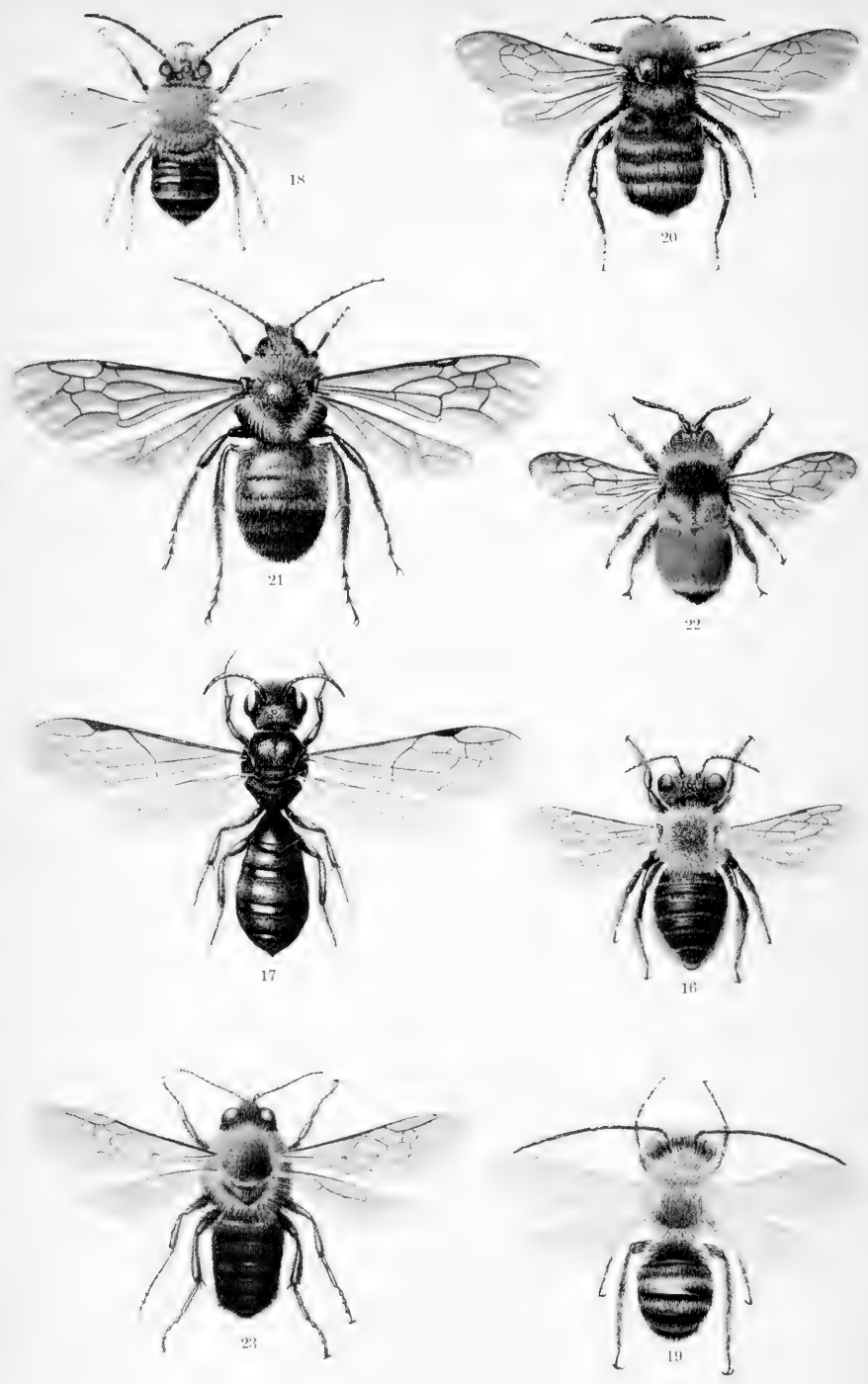


Fig. 93. *Myzine sexmactata* Fab. female=*Elis quinquemaculata* F.

SAPYGIDAE

Females winged. Wings, when present, not folded longitudinally in repose; a constriction between first and second abdominal segments; legs as in *Scoliidae*; sternellum not defined; intermediate coxae usually contiguous; tibiae not flattened; apex of abdomen in male without appendages; eyes deeply emarginate; abdomen usually marked with yellow or white.

All species said to be parasitic though some are reported as guests in the nests of some bees. The genus *Sapyga* has smooth slender body ornamented with yellow; it lays its eggs in the cells of *Osmia*, the larva consuming the stores which the latter has laid up for its young. One species of *Sapyga* has been bred from *Pelopaeus cementarius*.



I. L. WOOD, DEL.

LUC. ENGRAVING, MDIS.

MINNESOTA HYMENOPTERA

Plate 3.

METHOCIDAE

Wings, when present, not folded longitudinally in repose; constriction between first and second abdominal segments; legs of usual length; posterior femora when directed backward not reaching to middle of abdomen; sternellum not defined; intermediate coxae generally contiguous; tibiae not flattened; clypeus transverse, very much wider than long; eyes usually entire; female thorax divided into three parts; apex of abdomen of male armed with single spine.

The family is a small one, the Connecticut volume listing only one genus and species. *Methoca stygia* Say, described by Say under the name of *bicolor*, "has a black head, while the remainder of the insect is almost entirely castaneous. The male is black with the wings dusky." This species resembles an ant.

MYRMOSIDAE

Same as *Methocidae*, but female thorax divided into two parts, prothorax being well separated; apex of abdomen in male without spines; females always apterous.

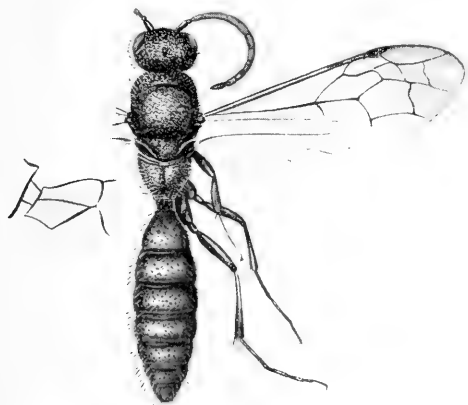


Fig. 94. *Myrmosa unicolor*. Male.

We figure a male *Myrmosa unicolor* which occurs in Minnesota and is of general distribution over the U. S. and Canada.

MUTILLIDAE

Same as *Myrmosidae*, but female thorax undivided; apex of abdomen in male with two spines.

All parasitic, and for the most part in the nests of wasps or bees wherein at times they may play the part of guests.

There is a striking difference between the sexes; the females are wingless, the males winged. (Morawitz states that "wingless males occur in two species.") They closely resemble ants but have no node or knot at base of abdomen. The females are provided with powerful stings. Members of the family are also characterized by a velvet-like

EXPLANATION OF COLORED PLATE 3

16. *Megachile (Xanthosarus) latimanus* Say.
17. *Ceratina dupla* Say.
18. *Xenoglossa (Peponapis) pruinosa* Say.
19. *Melissodes* sp.
20. *Bremus borealis* Kby.
21. *Psithyrus laboriosus*, var. *contiguus* Cress.
22. *Bremus ternarius* Say.
23. *Bombias separatus* Cress.

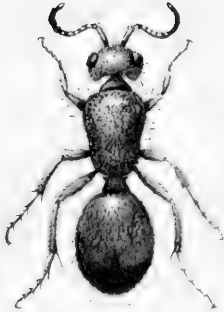


Fig. 95. *Dasytutilla vesta* Cress.

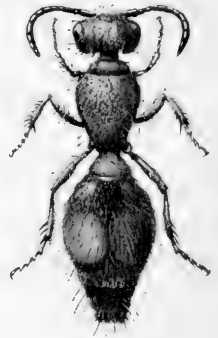


Fig. 96. *Dasytutilla cypris* Blake.

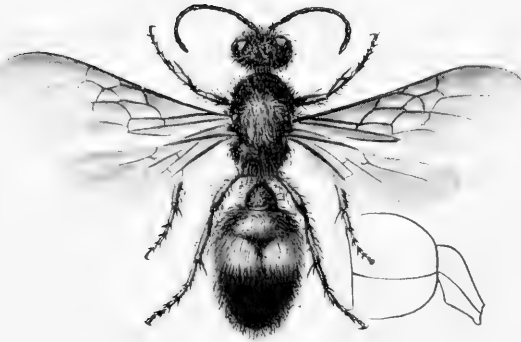


Fig. 97. *Dasytutilla bioculata* Cress.

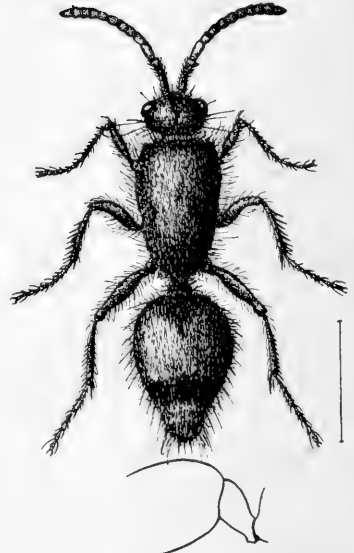


Fig. 98. *Dasytutilla ferrugata* Fab

pubescence over their bodies, upon which occur sharply outlined markings of bright colors, or ivory-like spaces. Some of the species are bright red, others yellow or orange. They are frequently called "velvet ants," also "cow ants" and "cowkillers." The family is distributed over the entire world, but is apparently most common in South America. About two hundred species occur in the United States, largely in the southwest.

Dasymutilla ferrugata F., *D. macra* Cress., *D. cypris* Blake, *D. (Bruesia) asopus* Cress., *D. vesta* Cress., *D. bioculata* Cress., *Nomiaephagus sanbornii* Blake, *Mutilla (Sphaerophthalma) mutata* Blake occur in Minnesota.

PSAMMOCHARIDAE

(*Pompilidae*)

Wings not folded longitudinally in repose; a constriction between first and second abdominal segments; legs very long, posterior femora when directed backward extending beyond middle of abdomen.

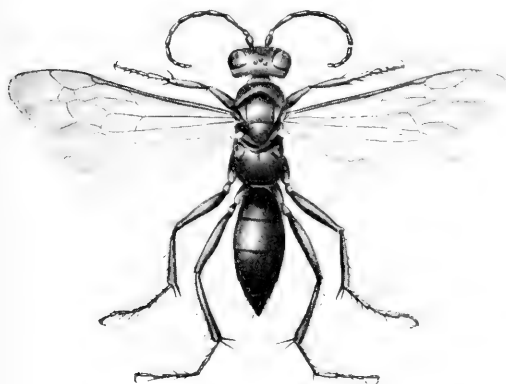


Fig. 99. *Psammochares scelestus* Cress.

These are slender long-legged wasps with abdomen united to thorax by a very stout stalk. They are generally velvety black or blue, often with orange bands; wings are usually black and constantly kept in jerky motion while the insect is moving about.

The family is almost cosmopolitan in its range. The species are large, many reach 2 or 3

inches in length. They are frequently seen running rapidly over the ground "with quivering wings and vibrating antennae." Their sting is capable of inflicting a painful wound. Spiders are their special prey and they can easily conquer the largest spider. They are frequently called "spider wasps." Their nests, usually in sand, are stored with spiders and caterpillars. In Texas, *Pepsis formosus* Say attacks tarantulas and is called "the tarantula killer." For an interesting account of the habits of *Pompiloides (Pompilus)* and *Agenia*, see "The Spider Ravishers" by G. W. and E. C. Peckham, p. 125 et seq. Wisc.

Geol. and Nat. Hist. Survey Bull. No. 2, Sci. Series No. 1. For Fabre's observations on *Calicurgus* see p. 157 "The Life and Love of the Insect." See also quotations from Fabre on pp. 101, 102, 103 Vol. VI, Camb. Nat. History.

Perez states that when *Pompiloides* has obtained a spider to provision its nest, it is sometimes pursued by *Ceropales*, another *Psammo-*

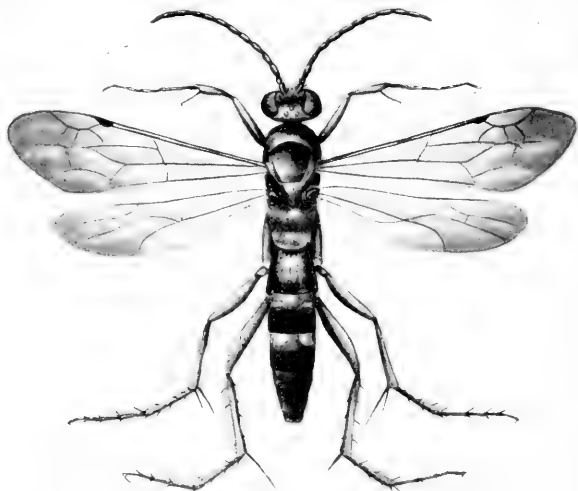


Fig. 100 (*Psammochares*) *Episyron biguttatus* Fab.

charid, which lays an egg on the spider, thus providing food for its own young.

The following occur in Minnesota (*Pompilus*) *Psammochares argenteus* Cress.; (*P.*) *P. tenebrosus* Cress.; (*P.*) *P. scelestus* Cress.; (*P.*) *P. luctuosus* Cress.; (*Psammochares*) *Episyron biguttatus* Fab., *Agenia* sp. *Psammochares* sp. taken in Rock Co. in Sept. and *Cryptochelil* in Itasca Co. in Aug.

EUMENIDAE

Wings always present and folded longitudinally in repose; claws dentate; two forms, males and females; middle tibiae with one or two apical spurs.

These are solitary, predatory wasps storing their cells with various kinds of insects. They may bore in pith or in wood, or make mud nests. It is the only family of solitary wasps whose members fold their front wings longitudinally as social wasps do.

The common so-called "potter wasp" *Eumenes fraterna* occurs here. It attaches its graceful vase-like mud nests, frequently with small stones imbedded in the wall, to low plants and

bushes. These nests are said to have served as models for early Indian pottery.

The group is of great economic importance, valuable to fruit growers and farmers, for its members prey upon caterpillars and larvae of beetles, many thousands of which it destroys each year. Sometimes as many as from six to a dozen are found in one cell. Caterpillars are first paralyzed by being stung, and, to insure safety for the single egg, the latter is suspended by a thread from the roof of the cell. The different species destroy numbers of tineids, geometrids, tortricids, and noctuid moths during the season.

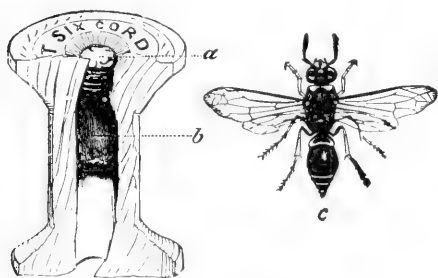


Fig. 101. *Odynerus flavipes* and its nest built in a spool. After Riley.

There is no worker caste in this family, all duties being performed by the perfect female. A few of the species resemble "yellow jackets" so closely that they fill one with alarm.

In some genera, *Eumenes* for example, the pedicel at the base of the abdomen is very elongate, while in others, it is strikingly short. In fact, *Odynerus* has a sessile abdomen.

Odynerus capra Sauss. provisions its cells with the larvae of the destructive larch saw-fly. This genus lives in holes in walls, in posts or other woodwork, in burrows in earth, or in stems of plants.

Ashmead states that in Florida he has observed *O. errynis* St. Farg. making its nest in the lock of his front door and in old holes in his board fence. He also reared it many times from cells constructed in old oak galls. C. V. Riley found an *Odynerus* cell in the tunnel through the center of a spool. Fig. 101.

The following species may be credited to Minnesota: *Odynerus* (*Ancistrocerus*) *capra* Sauss., *O. foraminatus* Sauss., *O. molestus* Sauss., (see colored plate 1.) *Eumenes fraterna* Say, on Aster in Aug. and Sept., *Odynerus* sp. taken at Itasca Park, Itasca Co. Aug. 22 and 29 and Sept. 1, in Roseau Co. Aug. 19 and in Rock Co. Sept. 11.

VESPIDAE

Same as **Eumenidae**, but claws simple. Three forms, females, males, and workers; abdomen either sessile or petiolate.

This family contains our social wasps, living in communities and constructing dwellings of papery-like material. This is made of woody

fiber, gathered from old fences, sheds, etc., chewed up and cemented by glandular secretion. A colony consists of males, females and workers, the latter being imperfect females. These carry on all the industrial work of the colony while the perfect females are egg laying. The nests are only used for a single season, the cold weather of fall killing off all but the young females. Even in the tropics, the colonies die off annually. While *Vespula arborea* and *V. sylvester* and *V. norvegica*, as well as others, suspend their nests from trees, bushes and elsewhere, *V. germanica* and *V. vulgaris* form nests below the surface of the ground.

Females that have hibernated, start their cells in early part of summer; "the solitary female wasp begins by making three saucer-shaped receptacles in each of which she deposits an egg; she then proceeds to form other similar shaped receptacles, until the first eggs deposited are hatched and the young grubs require a share of her attention. From the circular bases, she now begins to raise her hexagonal cells, not building them up at once, but from time to time, raising them as the young grubs grow." Proc. Ent. Soc. London 1858 p. 52.

Next to *Polistes*, *Vespula* (*Vespa*) is the most abundant genus. Members of both of these genera feed their young upon the chewed up fragments of Lepidoptera and other insects. Adult yellow-jackets feed on meat, fresh or decaying, on insects, dead fish, exposed fruit, raw or preserved, and on all sweet material. *Vespula* (*Dolichovespula*) *maculata*, the bald-faced hornet, is perhaps the best builder of globe nests; *V. germanica* and *V. cuneata* ("yellow jackets") usually build in hollows in stumps or in stone fences or underground. Sometimes, however, their nests are found suspended from bush, tree or building. One may see in the spring, the single comb nest made by the queen of *Vespula*, suspended from bush or elsewhere, partially enclosed in paper covering.

Both *Polistes* and *Vespula* are subject to parasites; the former is sometimes parasitized by *Xenus* a beetle belonging to the Stylopidae. *Vespula* is attacked by Stylopids, and by at least two species of Ichneumonids.

Underground wasp nests, which may become very large, can be destroyed by pouring into the nest at dusk, a little bisulphide of carbon. The large paper nests of hornets may be rendered untenable by drenching them with kerosene. It is safer to do this after dark if possible.

If the drenched nest is not attached to a building or fence, it may be burned after this application of kerosene.

Minnesota species are as follows: *Vespula vidua* Sauss., *Vespula* (*V.*) *germanica* F., *V.* (*V.*) *vulgaris* L. (see col. pl. 1), *V.* (*V.*) *consoabrina* Sauss., *V.* (*Dolichovespula*) *maculata* L., *V.* (*D.*) *diabolica* Sauss., *Polistes pallipes* Le.P=*P. metricus* Say. *Polistes* sp. taken in Rock Co., Fillmore Co., and Martin Co. in Sept.

NOMENCLATURE OF WING PARTS IN THE DRAWING OF

Chlorion (Ammobia) ichneumoncum

OLD SYSTEM

COMSTOCK-NEEDHAM SYSTEM

Front Wings

Veins	Veins
Costal	Costa or C
Subcostal	Sc+R+M
Median	Cubitus or Cu
Submedian or anal	A
Radius or marginal	{ 1st abscissa, radial cross-vein or r, 4th abscissa R ₃ ; recurved tip Sc ₂ + R ₁₊₂
Basal	Medio-cubital cross-vein and Media
First transverse cubital	R ₃ and r-m
Second transverse cubital	R ₅
Third transverse cubital	R ₄
Transverse medial	M ₄ +Cu ₁
Discoidal	1st abscissa M ₄ , 2d abscissa M ₃
Cubital	M+R ₁₊₂ ; at margin M ₁ +R ₁₊₂
First recurrent	M ₃₊₄
Second recurrent	Transverse part of M ₂
Subdiscoidal	{ (1st abscissa) medial cross-vein { (2d abscissa) M ₂
Cells	Cells
Costal	C+Sc
Median or externo-medial	M
Submedian or interno-medial	Cu+Cu ₁
Anal	1st+2d+3d A
Marginal or radial	2d R ₁ +R ₂
First submarginal or cubital	1st R ₁ +R
Second submarginal	R ₃
Third submarginal	R ₄
Fourth submarginal	R ₅
First discoidal	M ₄
Second discoidal	M ₃
Third discoidal	1st M ₂
First apical	2d M ₂
Second apical	M ₁
Stigma	Stigma or cell Sc ₂

Hind Wings

Veins	Costa or C	Veins
Costal	R+M	
Subcostal	Cu and M ₁	
Median	1st A; at tip 1st A and 2d A	
Anal	R ₃ (at its tip)	
Radian or marginal	m-cu and R ₁₊₂ +M ₁	
Cubital	m and M ₂	
Discoidal	M ₃	
Transverse median	Free part of media or M	
Transverse cubital	3d A	
Axillary		
Cells	C+Sc+Sc ₁	Cells
Costal	M	
Median	Cu+Cu ₁ +M ₃	
Submedian	1st A+ 2d A; 3d A	
Anal	R ₁₊₂	
Marginal or radial	R+R ₃ +R ₄ +R ₅	
Submarginal or cubital	M ₁ +1st M ₂ +M ₄	
1st discoidal	2d M ₂	
2d discoidal.		

SPHECOIDEA

Abdominal segments not strongly differentiated as petiole and gaster; tegulae present, wings usually well developed, sometimes vestigial or lost; pronotum with its hind angles or tubercles always distinctly remote from tegulae; hairs of dorsulum simple not branched or plumose; abdomen with more than three segments visible, segments beyond third not hidden.

This superfamily includes the solitary wasps (see also *Eumenidae*, superfamily *Vespoidea*) which for the most part make burrows and store their nests with insects which they have paralyzed by stinging. For an interesting account of life history and habits of insects in this group, see the excellent treatise by G. W. and E. G. Peckham of Milwaukee "On the Instincts and Habits of the Solitary Wasps," Bulletin No. 2, Scientific Series 1, Wisconsin Geological and Natural History Survey. Students should also read pp. 18 et seq. in L. O. Howard's "Insect Book," Doubleday, Page and Co., 1904. The student should also consult Fabre's "The Hunting Wasps," Dodd, Mead & Co., 1915. Fabre's observations are by no means confined to wasps of this superfamily.

AMPULICIDAE

Mesosternum produced posteriorly into an elongate process which is cleft or bifurcate apically; middle tibiae with two apical spurs; prothorax long; femora swollen near middle; abdomen petiolate, no constriction between the first and second segments.

Species in this group are very rare. An European species lives on cockroaches. The only genus listed in the Hymenoptera of Connecticut is *Rhinopsis*, small wasps, not quite $\frac{1}{2}$ inch long, black.

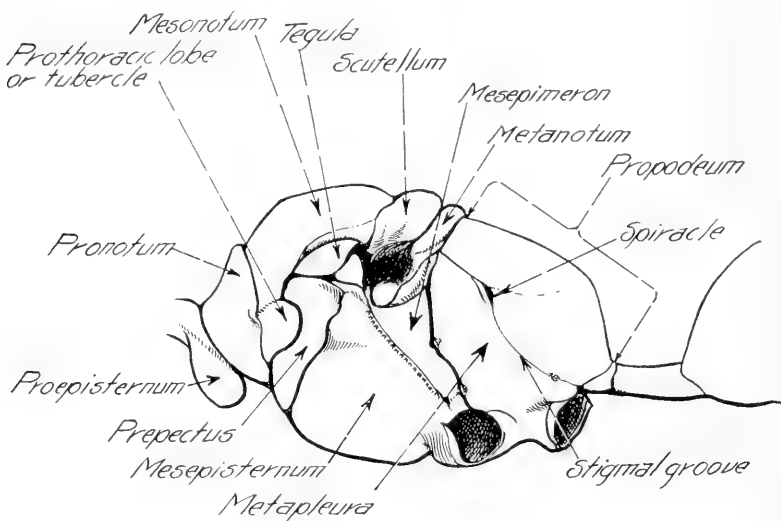


Fig. 103. Thorax of *Chlorion (A.) ichneumoncum*.—From *The Hymenoptera of Conn.*

NYSSONIDAE

Labrum entirely covered by clypeus, or at most with only apex visible; mesosternum normal, not produced into a forked process posteriorly; middle tibiae with two apical spurs; abdomen sessile or sub-sessile, without a constriction between the first and second segments.

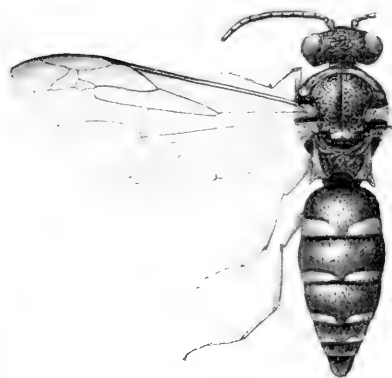


Fig. 104. *Nysson aequalis* Patten.

Nysson, *Alyson*, *Gorytes*, and other representative genera nest in sand. We have but little knowledge of their habits.

The following species are found in Minnesota: *Pseudoplisus phaleratus* Say, *Nysson mellipes* Cress., *Gorytes albosignatus* Fox, *G. canaliculatus* Say, *Alyson trianguliferum* Prov., *A. oppositus* Say, *A. melleus* Say.

PSENIDAE

Antennae inserted near middle of face; mesepisternum with a dorsal and ventral plate; abdomen petiolate; wings with three cubital cells.

This family has the rank of a sub-family (*Pseninae*, Family *Sphecidae*) in the "Hymenoptera of Connecticut."

The family is fairly well represented in Canada and the United States. *Psen concolor* provisions its nest in hollow stems with *Psyllids*. In 1913 *Psen (Pemphredon) tenax* was reported as attacking roses in the Toronto district.

OXYBELIDAE

Head transverse; scutellum margined; post scutellum armed with a spine, thorn or forked process and with squamae; front wings with the first discoidal cell obliterated, rarely distinct, most frequently confluent with the second discoidal cell. First cubital and first discoidal cells confluent. Eyes with their inner margins sub-parallel.

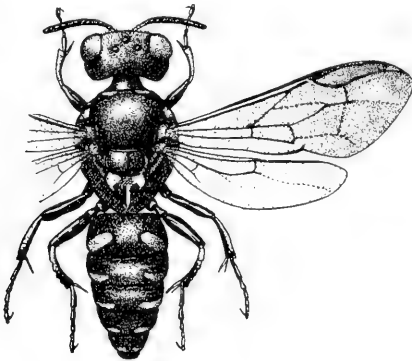


Fig. 105. *Oxybelus subulatus* Rob.

These small wasps burrow in the sand and provision their nests with flies, not stinging them, but crushing the thorax and thus destroying the principal nerve ganglia. The Peckhams found in some of the burrows of *Oxybelus quadrinotatus* a dozen flies in the same nest, all with the thorax crushed.

We figure *O. subulatus* as a Minnesota species.

CRABRONIDAE

Head large, quadrate or trapezoidal; scutellum normal, post scutellum unarmed; front wings with the first discoidal cell always distinct; front wings with only one sub-marginal cell; middle tibia with only one apical spur. Eyes with their inner margins strongly converging below.

Sometimes popularly referred to as "sand wasps." Over one hundred species of this family are known. They exhibit great diversity of habits. Westwood says, "Those (species) whose economy has been clearly traced, make their cells in wood, boring into palings, posts, willows, stumps, pithy stems, etc. Their fore feet are well adapted for digging and tunneling. Members of this group, like the preceding, are said to crush the thorax of their prey, thus paralyzing the chief

nerve centers, rather than stinging their victims. Their nests are provisioned largely with Diptera, though they also attack caterpillars, spiders, aphids and other insects.

Crabro stirpicola was observed by the Peckhams to work night and day for forty-two consecutive hours.

Minnesota species: *Crabro trapezoides* Pack., *Thyreopus* sp., *Crabro (Rhopalum) pedicellatum* Pack., *Solenius (Xestocrabro) sayi* Ckll. (See col. plate 2.) *Anacrabro ocellatus* Pack. Unidentified species of *Crabro* were taken by Viereck on aster, golden rod and achillea, at Itasca Park during Aug. 1913 and in Roseau Co. near Lake of the Woods.

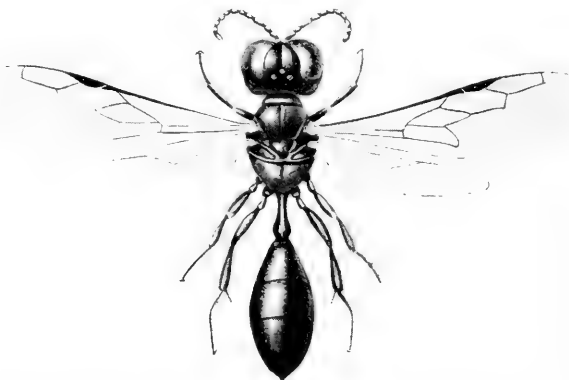


Fig. 106. (*Crabro*) *Rhopalum pedicellatum* Pack. Female.

PHILANTHIDAE

Head wider than the thorax; eyes most frequently normal, sometimes slightly emarginate within, rarely deeply emarginate within; front wings with three submarginal cells, intermediate tibiae with two apical spurs; abdomen frequently sessile or sub sessile, rarely petiolate, not elongate, first segment frequently with a deep constriction between the first and second.

Members of this family look something like wasps. The males exhibit brushes of long hairs on each side of the clypeus. Honey bees are frequently their victims. *Philanthus triangularis* Fab. according to Latreille, digs burrows in hot sandy situations and provisions its nest with honey bees. A single bee is sufficient for rearing one wasp. Living with the honey bee, which is defenceless against its armor, this species stings its unsuspecting host on the under surface

of the mentum; "afterwards the poor bee is subjected to a violent process of kneading by which the honey is forced from it." It is then carried to the burrow of *Philanthus*. This burrow may be a yard long.

Some very interesting and original observations upon this species are to be found on pp. 150 to 178 in Fabre's *Social Life in the Insect World*, Century Co. 1913, and reference to the same species are to be noted in "The Hunting Wasps" by the same author.

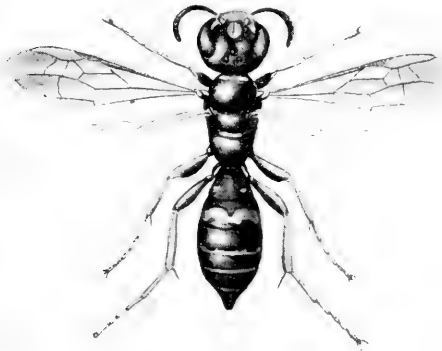


Fig. 107. *Philanthus dubius* Cress., male.

The habits of *Philanthus punctatus* are discussed at length in the Wisconsin volume above alluded to. *Aphilanthops frigidus* Sm. provisions its nest with queen Ants (Wheeler "Jl. of Animal Behavior," Vol. III, 374-387, 1913.)

The habits of *Philanthus punctatus* are discussed at length in the Wisconsin

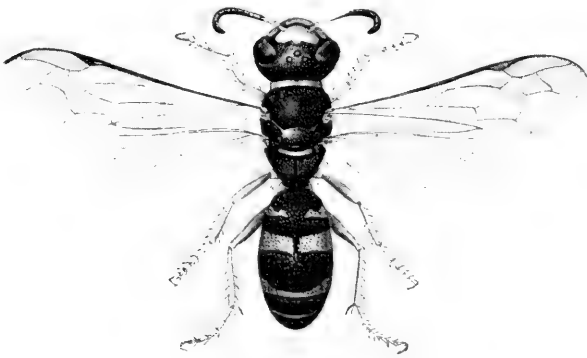


Fig. 108. *Philanthus ventilabris* Fab., male.

P. (Philanthus) punctatus Say, *P. (P.) dubius* Cress., and *P. (Pseudanthophilus) ventilabris* Fab. are on record as occurring in Minnesota. *Philanthus gibbosus* Fab. taken by Viereck Sept. 10 in Rock Co., and *Philanthus* sp. taken along lake shore in St. Louis Co., Aug. 15. *Eucerceris zonata* Cress. was collected at Gray Cloud Island, Minn., in August. For an illustration of *P. (P.) solivagus* Say, see Howard's *Insect Book*, Pl. III fig. 3.

TRYPOXYLONIDAE

Head not wider than the thorax; eyes always deeply emarginate within, or reniform; front wings with two submarginal cells, the second more or less indistinct; middle tibia with only one apical spur; abdomen elongate, clavate, first segment elongate, petioliform; a strong constriction between the first and second abdominal segments.

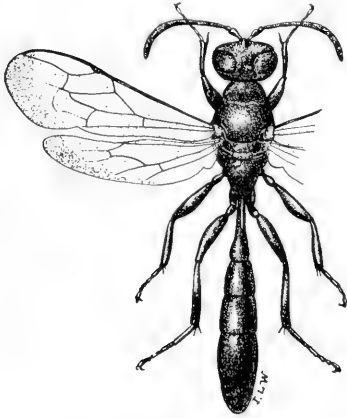


Fig. 100. *Trypoxylon bidentatum* Fox, female.

These are slender wasps without yellow bands on abdomen. They make cells in pithy plants, separating them by mud partitions, or they make mud cells against walls near or in houses. These nests are stored with spiders. Some of them, *Trypoxylon albitarse*, for example, according to Walsh, select the deserted cells of a mud dauber, provisioning its nest with spiders. Another species, *T. carinifrons*, stores its cell with aphids. We figure a female of *Trypoxylon bidentatum* Fox, from a Minnesota specimen.

MELLINIDAE

Mesosternal suture wanting; intermediate coxae contiguous; middle tibia with two apical spurs; abdomen with a more or less distinct constriction between the first and second segments, first segment coarctate.

There is only one genus of this family, containing three species, in America. There are therefore scanty if any observations on the group in this country. Members of the genus *Mellinus* have been observed on patches of cow dung feigning death, only to grasp a blue bottle fly which came within reach.

The European species *M. arvensis* provisions its nest with small Diptera, including *Stomoxys calcitrans*, the stable fly.

SPHECIDAE

Antennae inserted above the base of the clypeus. Mesosternum not produced into an elongate process; prothorax usually transverse; femora normally not swollen in the middle; prepectus present; abdomen distinctly petiolate, no constriction between first and second segments.

Comstock calls these "thread-waisted" wasps because the most striking characteristic is the fact that the first segment of the abdomen forms a long, smooth, round petiole suggesting the name. Unlike the

bees, the legs of these wasps are adapted only for digging and walking. They love the sunshine and move actively about in the heat. Provided with a powerful sting, they are enabled to paralyze their prey (insects) by stinging the principal nerve ganglia. Their victims stored in their nests as food for their larvae, live many days but are incap-



Fig. 110. *Pseudoplisus phaleratus* Say.

able of movement which would endanger the life of the sphecid egg or larva. Caterpillars so stung may transform to pupae but are too weak to carry the transformation further. Members of this family either make nests in sand or act as "mud daubers," building their cells of mud and plastering them on walls.

Ammophila (*Sphex*) is a genus of giants. Many of them prey upon the large Cicadas or harvest flies, easily carrying them off to their nests. *S. ichneumon* sometimes called the "great golden digger," is a common form in the United States. Packard reports seeing in late summer or early autumn nearly a dozen of these wasps engaged in digging holes in a gravelly walk. These holes were from four to six inches deep.

This genus also preys upon crickets. These insects, tho paralyzed, survive for several weeks (Fabr.). Three or four crickets are sometimes found in each cell and a single *Sphex* may destroy one hundred or more crickets in this way. The egg is placed on ventral surface of victim between 2nd and 3rd pairs of legs, and hatches in three or four days. In six or seven days, the larval *Sphex* has completely eaten out the insides of the cricket, and it then attacks another. In ten or twelve days the stock of crickets is exhausted.

S. W. Williston reports (Ent. News Vol. III p. 85), that *Ammophila* (*Sphex*) *yarrowi* Cr. has been observed to bury four or five caterpillars, storing them in her burrow for food of her future off-

spring. He further says, "the things that struck us most, were the most unerring judgment in the selection of a pebble of precisely the right size to fit the entrance and the use of the small pebble in smoothing down and packing the soil over the opening, together with the instinct that taught them to remove every evidence that the earth had been disturbed."

The relative strength of wasps of this genus is surprising. Ashmead saw *A. (Sphecx) cementaria* Smith, after paralyzing a half grown Sphinx larva by stinging, seize it just back of the head with its jaws and since it was too heavy a burden to fly with, straddle it, and drag it off to its cell, *moving forward*. A European species has been observed "dragging a very large inflated spider up the nearly perpendicular side of a sand bank at least 20 feet high."

Ammophila pictipennis provisions its nest with cutworms. The steel-blue *Chalybion caeruleum* stores in its burrows, crickets, locusts, and spiders.

Minnesota species: *Chlorion (C.) cyaneum* Dahlb., *C. (Palmodex) abdominalis* Cress., *C. (Priononyx) atratum* LeP., *Sphecx (Psammophila) luctuosa* Sm., *Chalybion caeruleum* L. *Sceliphron cementarius* Drury, *Chlorion (Ammobia) ichneumoneum* L. (see col. pl. 2). *Sphecx pictipennis* Walsh, *S. robusta* Cress., *Chlorion (A.) pennsylvanicum* L. For illustration of the latter see Howard's Insect Book, Pl. VII, fig. 20.

Sphecx sp. has been taken in Rock and Fillmore Counties in September.

LARRIDAE

Eyes most frequently normal, rarely emarginate within; hind ocelli normal or aborted, or wanting; labrum small, not free; usually completely hidden by the clypeus; mandibles often emarginate on the under side; front wings with a distinct stigma, and with two or three submarginal cells; middle tibiae with only one apical spur; abdomen sessile, never petiolate; no strong constriction between the first and second segments.

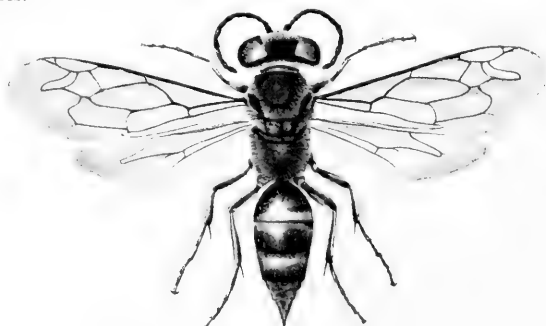


Fig. 111. *Tachysphec terminatus* Sm.
female.

These wasps make burrows in sandy places and provision their nests chiefly with grasshoppers and crickets.

They are active insects and very hard to net in the field. The small *Lyroda subita* feeds its young daily with crickets. We have recorded as occurring here *Tachytes crassus* Patt. and *Tachysphex terminatus* Sm.

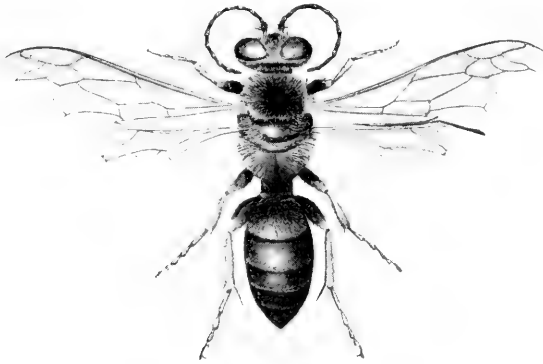


Fig. 112. *Tachytes crassus* Patton,
male.

ASTATIDAE

Abdomen depressed, dorsal surface flattened; intermediate tibiae with two apical spurs; radial cell truncate; wings with three cubital cells. (Listed as a subfamily in Conn. Hym.)

The males of this family are characterized by the possession of very large eyes. Members of the group are partial to the Heteroptera in the matter of food. At least two species select bugs and do not paralyze, but kill them.

PEMPHREDONIDAE

Eyes normal, not emarginate within; ocelli distinct; labrum most frequently hidden; front wings with two submarginal cells; middle tibia with only one apical spur; abdomen sessile or petiolate, without a constriction between the first and second segments. (Listed as a sub-family in Hym. of Conn.)

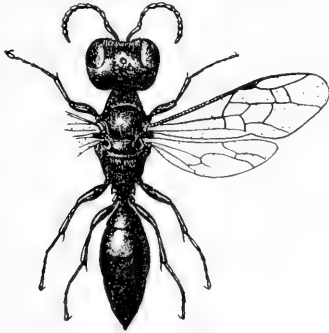


Fig. 113. *Pemphredon tenax* Fox, female.

These are rather small, slender wasps, of a shiny black color, which burrow in pith of dry branches, making very irregular and complicated channels. They frequently store their nests with plant lice.

Pemphredon tenax Fox, occurs in Minnesota, and *Stigmus* sp. has been taken in St. Louis Co. in August.

BEMBICIDAE

Antennae inserted close to clypeus; cheeks narrow, prepectus wanting; eyes normal, not emarginate within; ocelli aborted, represented by scars; labrum large, free, well developed, much longer than wide, triangularly elongated; front wings with three submarginal cells; abdomen sessile, never petiolate, no strong constriction between first and second segments; otherwise as in *Sphécidae*.

These wasps nest in the ground, frequently in colonies, and provision their nests with Diptera or Hemiptera. The biology of this group, particularly of *Bembex*, has been treated by various observers. An extremely interesting account of *Bembex* occurs in Fabre's "The Hunting Wasps." To the question as to why *Bembex* does not paralyze her prey by stinging, Fabre replies that her abdomen is so formed that she cannot do so. Parker (Proc. U. S. Nat. Mus. Vol. 52 p. 123 et seq.) discusses at length the biology of the Bembicidae and in the course of his remarks states his belief that a Bembicid wasp finds her skillfully concealed burrow by the sense of smell, citing several instances where he greatly disturbed the surface over the burrow, even to the extent of dashing water over it, but never succeeded in confusing the female wasp.

A prominent member of this family is *Sphécus speciosus* Say, the giant sand wasp or "cicada killer," which provisions its burrows with different species of Cicadas. A Florida species preys upon the large horse fly *Tabanus atratus*. Coquillett reported frequently observing, in California, *Bembex fasciata* storing its nest with *Eristalis tenax* and other flies. Members of the genus *Stizus* (large hairy bodied wasps) paralyze grasshoppers and other large insects (including the dog-day cicada) and carry them off to their burrows.

The sense of direction appears to be well developed in this group, for they cover their burrows so adroitly that there appears to be absolutely nothing by which the exact position of the nest can be traced. Yet *Bembex* flies to it without failing. At least one species, *Bembex spinolae* supplies flies to the growing larva during the life of the larva, digging away the soil from the entrance of the nest each time and scraping it together again when she leaves the nest. *B. rostrata* also makes frequent visits to its nest with fresh food.

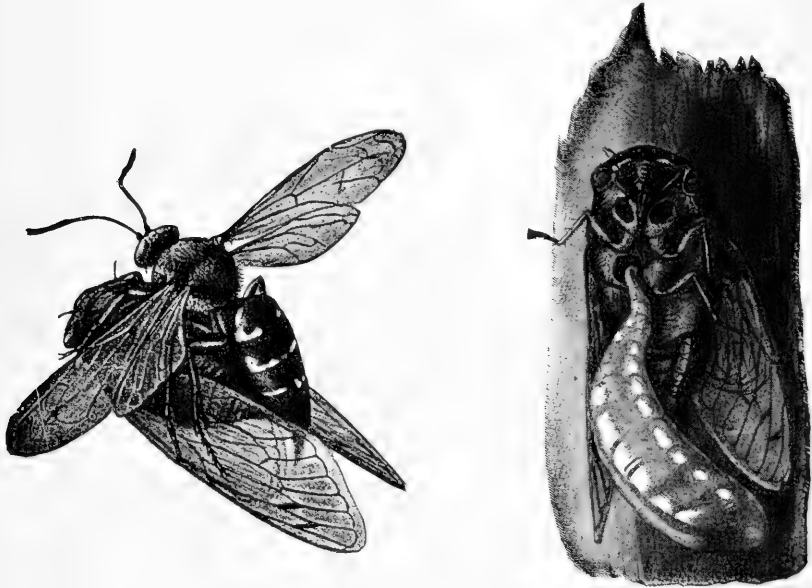


Fig. 114. Left figure *Sphecius speciosus* Say, carrying a Cicada to her burrow. Right figure, Cicada in burrow of *Sphecius* with full-grown larva of digger wasp feeding.—From *Insect Life*.

A Tachinid fly of the genus *Miltogramma* lays eggs on victim being carried to burrow by *Bembex*, and its maggot later eats this store of provisions intended for the young *Bembex* larva.

Minnesota species: (*Bembidula*) *Bicyrtes ventralis* Say (Rock Co. Sept.). For an account of the habits of this species see Parker, Proc. U. S. Nat. Mus. Vol. 52 p. 132 et seq.

B. quadrifasciata Say. Ibid., *B. spinolae* LeP., Ibid. *Microbembex monodonta* Say. (see col. pl. 2; also Vol. 52 Proc. U. S. M., p. 134 et seq.) *Bembex spinolae* LeP. was taken by Viereck in Sept. 1913 in Rock Co.

CERCERIDAE

Mesosternum not produced into an elongate process; femora normally not swollen in the middle, prepectus wanting; antennae inserted much above clypeus; cheeks broad, first abdominal segment much narrower than second; lower posterior margin of propodeum rounded; a dorsal plate to mesepisternum.

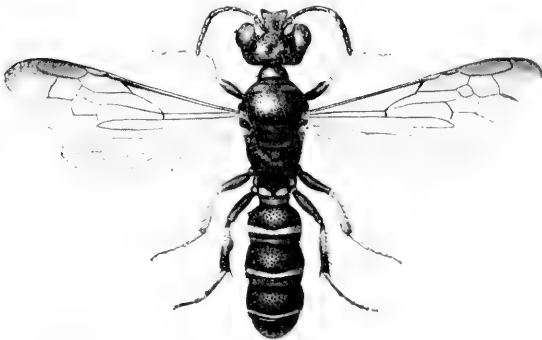


Fig. 115. *Cerceris fasciola* Cress., female.

Members of the genus *Cerceris* make burrows in the ground and store them with beetles. These beetles when captured are stung between the pro- and meso-thorax. Some European species store their nests with bees, others with beetles.

We figure *Cerceris fasciola* Cress., from a Minnesota specimen.

Viereck took *Cerceris* sp. on goldenrod and aster in Aug. and Sept. in Rock and St. Louis counties.

SUBORDER APOIDEA

A deep constriction at the base of the first abdominal segment, conspicuously separating the abdomen from the thorax; abdominal segments not strongly differentiated as petiole and gaster; tegulae present, wings usually well developed, sometimes vestigial or lost; pronotum with its hind angles or tubercles always distinctly remote from tegulae; hairs of dorsum branched or plumose.

With few exceptions, these are all "bee-like" in appearance, differing of course from certain bee-mimicking flies (Syrphidae and Bombyliidae) by the presence of two pairs of wings instead of one pair. Something like a thousand species are known to occur in North America. Individuals are more or less hairy, and the tongue is always formed for lapping, the hind legs are generally modified to carry pollen.

HALICTIDAE

Females and most males with a flat triangular area on the apical dorsal abdominal segment; clypeus hardly protuberant; labrum concealed except at base, posterior angle of mandible not in front of posterior margin of eye; tongue acute, flat, rarely filiform; labrum not free from mandibles and not as large as clypeus; hind metatarsus invariably narrower than tibia; marginal cell acute toward front edge of wing; basal vein forming more or less perfectly an arc of a circle; face with no pubescent depressions of foveae.

These are very small, for the most part short-winged solitary bees (i.e., no specially developed workers), some of them brilliantly

blue and green in color. Altho solitary in the above sense, they may occur in communities, a large number of individuals building in the same territory. While each bee works for its own progeny, there may be community labor as in making a gallery needed by a colony.

Work of excavating is carried on at night. The handsome little bees of genus *Halictus*, only about 1/100 to 3/100 of an inch long, often metallic in color, dig branched tunnels seven or eight or more inches long. They sometimes occur in large colonies on the sides of sand cliffs.

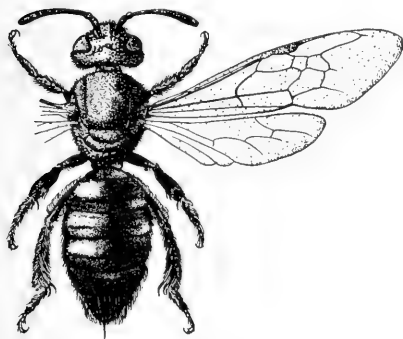


Fig. 116. *Halictus (Agapostemon) radiatus* Say, female.

Minnesota species: *Halictus (Halictus) lerouxi* var. *rubrum* Ckll., *Halictus (Agapostemon) virescens* F. (see col. plate 2.). *H. (A.) radiatus* Say, *H. (A.) texanus* Cress., *H. (A.) splendens* LeP., *H. (Chloralictus) tegularis* Rob. *H. (C.) pilosus* Sm., *H. (C.) pruinus* Rob., *Chloralictus*

vierecki Crwfd., *Augochlora* sp. and *Oxysloglossa* sp. (aster and golden rod, Itasca Co. in August), *Halictus lerouxi* Fab., lake shore, Duluth, St. Louis Co., *H. ligatus* Say, Rock Co. Sept. 11, on aster. *Chloralictus* sp. Itasca Co. in Aug., and Martin, Fillmore and Rock Cos. in Sept. on aster, sunflower and golden rod. *Evylyaeus* sp. Itasca Co., Aug. 25, on *Solidago*. *Lasioglossum* sp. taken on sunflower and aster by H. L. V. in Itasca Park, Aug. 29.

ANDRENIDAE

Same as **Halictidae** but basal vein forming a more or less perfectly straight line, and face with pubescent depressions or foveae, at least in female; hind femora always with a pollen brush, or flocculus.

These bees are of moderate or large size. They resemble honey bees, and are sometimes mistaken for them; generally, however, they are smaller. A large number of species is known, most of them diggers, and all of them solitary, although they almost always live in colonies, constructing burrows in the ground and preferring sandy places, sometimes, however, selecting a gravel path. *Andrena* "villages" have been

observed, covering only one square rod of ground, that included several thousand nests. The sexes are different in appearance and are rarely found together. The cells are stored with pollen and honey.

Minnesota species:

- Andrena imitatrix claytoniae* Rob., *A. (A.) erythrogaster* Ashm., *A. (A.) dunningi* Ckll. *A. (A.) carlini* Ckll. *A. (A.) bisalicis* Vier., *A. (A.) robertsoni* D. T., *A. (A.) commoda* Sm., *A. (A.) zigiae* Rob., *A. (A.) mariae* Rob., *A. (A.) flavoclypeata* Sm., *A. (Trachandrena)*



Fig. 117. *Andrena (A.) mariae* Rob., female with 2d dorsal abdominal segment on left and enclosure on propodeum on right.

- chandrena hippotes* Rob., *A. (Trachandrena) crataegi* Rob., *A. (A.) placida* Sm., *A. (A.) nubecula* Sm. (on goldenrod and aster, Martin and Rock counties in Sept.), *A. (A.) canadensis* Prov., *A. (A.) fragilis* Sm., *A. (A.) hirticincta* Prov., *A. (A.) cressoni* Rob., *A. (Pterandrena) helianthi* Rob. (on aster, Martin and Itasca counties in Sept.), *A. (P.) asteris* Rob.

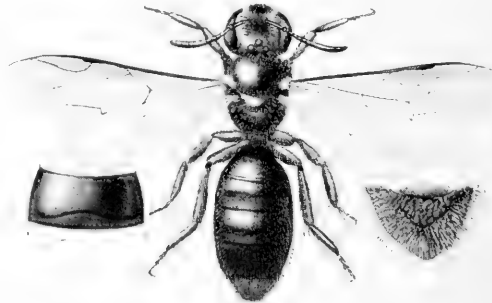


Fig. 118. *Andrena (T.) crataegi* Rob., female.

DUFOUREIDAE

Females and most males with a flat triangular area on apical dorsal abdominal segment; clypeus hardly protuberant, labrum concealed except at base, posterior angle of mandible not in front of posterior margin of eye; tongue acute, flat, rarely filiform; labrum free from mandibles and as large as clypeus.

Halictoides (Conohalictoides) novaeangliae Rob. is found in this state. Visits flowers of pickerel weed.

NOMIIDAE

Tegulae very large; glossa lance-linear, acuminate, shorter than mentum; mandibles bidentate, not bevelled; posterior angle of mandible not before posterior line of eye; clypeus hardly protuberant; labrum usually small, concealed except at base and with a basal process, metathorax produced beyond postscutel.

The type genus *Nomia* is a large one. *Nomia (Eunomia) heteropoda* Say occurs in Minnesota.

MACROPIDAE

Same as *Dufoureaeidae*, but labrum **not** free from mandibles and not as large as clypeus; hind tibia and metatarsus of equal breadth.

The genus *Macropis* occurs in this state (collected on Indian Hemp along lake shore, St. Louis Co., by H. L. V.) *M. ciliata* Patt. is sometimes found on *Lysimachia terrestris*.

PANURGIDAE

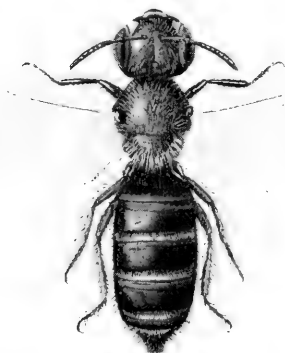


Fig. 119. *Calliopsis* sp.

taken here on aster and goldenrod (Rock, Fillmore and Martin Cos. in Sept.), *Calliopsis andreniformis* Sm. occurs in this state, as does also *Panurgus* sp.

Same as *Macropidae*, but hind metatarsus invariably narrower than tibia; marginal cell truncate toward front edge of wing.

We figure *Calliopsis* sp. and *Perdita* sp. collected in Minnesota. *Panurginus* has also been



Fig. 120. *Perdita* sp.

NOMADIDAE

Females and most males with a flat triangular area on apical dorsal abdominal segment; clypeus protuberant, or mandibles beveled so as to show all of labrum or a great portion of it; labrum large without a basal process, tongue filiform; first and second joints of labial palpi flat; first portion of sub-discoidal vein shorter than third portion of discoidal vein.

Small, not very hairy bees, somewhat resembling wasps. They are parasites in the nests of other bees. In accord with their parasitic

habits, their legs are not modified to carry pollen. These bees appear to live on the best of terms with their hosts, and their larvae are fed with the pollen and honey stored up by the latter.

Minnesota forms: *Epeolus scutellaris* Say, *Nomada* sp., *Gnathias* sp. *Triepeolus bardus* Cress. (see col. plate 2), *Centrias* sp. *Holonomada* sp. *Triepeolus* is found in late summer on the *Compositae*. *Nomada* is an early flier visiting aments of willow.

EUCERIDAE

Same as preceding family as to apical dorsal abdominal segment of males and females; also as to clypeus, mandibles and labrum, tongue, and first and second joints of labial palpi. But first portion of sub-discoidal vein distinctly longer than third portion, and marginal cell bent away from costal vein; vertex crested.

Often densely hairy, of moderate size. *Xenoglossa* is one of the chief agents in pollenizing the flowers of pumpkins, squashes, melons and cucumbers.

Cemolobus ipomoeae Rob. visits flowers of the morning glory. *Melissodes* (*Anthedon*) *compta* Cress. is illustrated in Howard's Insect Book, Pl. III and *Melissodes* (*M.*) *rustica* Say in Fig. 12 pl. IV, op. cit. *Tetralonia atriventris* Sm. is illustrated in Fig. 19, pl. II, op. cit.

Minnesota species: *Melissodes bimaculata* LeP., *M.* (*M.*) *rustica* Say, *M. nivea* Rob., *M. perplexa* Cress., *Tetralonia speciosa*, *Melissodes* sp. (see col. plate 3), *Xenoglossa* (*Peponapis*) *pruinosa* Say. We have taken *Melissodes* on aster in this state in Aug. and Sept. in Itasca, Martin and St. Louis counties.

EMPHORIDAE

Same as in **Euceridae** but vertex not crested.

There is no representative of this family in the Minnesota collection. *Melitoma taurea* Say is figured in Howard's Insect Book, Pl. III, fig. 7, *Emphor bombiformis* Cress. visits flowers of morning glory (*Ipomoea*) and marshmallow (*Hibiscus*).

ANTHOPHORIDAE

Same as **Emphoridae**, but marginal cell not bent away from costal vein.

These solitary bees are, in size, between a honey bee and bumble bee. They are for the most part hairy and many burrow in the soil, forming cells in underground tunnels and laying their eggs therein upon a mixture of pollen and honey. The cell is then closed. Some

species in this family bore into wood, or they may occupy old burrows of some carpenter bee. (Howard)

Anthophora (Clisodon) terminalis Cress, is the only species on record in the state, taken on aster at Itasca Park in August.

HYLAEIDAE

Females and most males without a flat triangular area on apical dorsal abdominal segment; second recurrent vein bent or directed outward before joining first portion of subdiscoidal vein; tongue flat, bilobed; depressions or fovae on face; wings with two closed submarginal cells; black and yellow markings.

These are the bees that Ashmead called the "obtuse-tongued carpenter bees." But few of them are parasitic. They burrow in the pithy twigs of shrubs, frequently elder, where they construct their cells, filling them with pollen and honey. *Hylaeus* sp. occurs in the state, taken on aster in St. Louis Co. in August.

COLLETIDAE

Same as *Hylacidae*, but wings with three closed submarginal cells; black *without* yellow markings; head and thorax more or less clothed with a dense pubescence; tongue flattened and broad. Hind femora, tibia and tarsi of females always with a pollen brush or flocculus.

Moderate sized blunt tongued hairy bees, burrowing in sandy places.

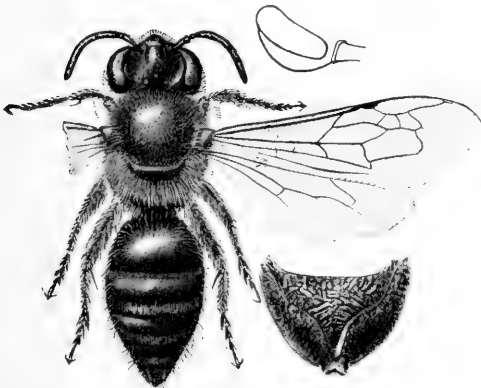


Fig. 121. *Colletes compactus* Cress.

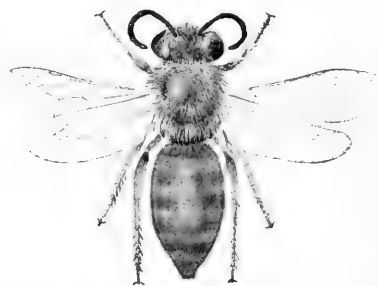


Fig. 122. *Colletes americanus* Cress.

The females resemble somewhat the workers of the honey bee, but the males are much smaller. Their burrows are lined with a delicate parchment-like membrane, and are divided into several cells, six or more, by parchment-like partitions. An egg is deposited in each cell on or in a mixture of pollen and honey.

In Europe *Colletes* is parasitized by *Miltogramma punctata*, a tachinid fly, which lays its own egg in the cell on the food intended for the *Colletes* larva. Another parasite of this genus is the cuckoo-bee, *Epeolus variegatus*.

We figure *Colletes compactus* Cress., and *C. americanus* Cress. from Minnesota specimens. The first named has been collected from flowers of *Solidago* and asters. *Colletes* sp. has been taken in Hubbard, St. Louis and Itasca counties in August.

STELIDIDAE

Females and males as in **Hylaeidae** but second recurrent vein never strongly bent or directed outward before joining first portion of subdiscoidal vein; tongue filiform; no depressions or foveae on face. Wings with two submarginal cells; claws left, inner tooth subapical.

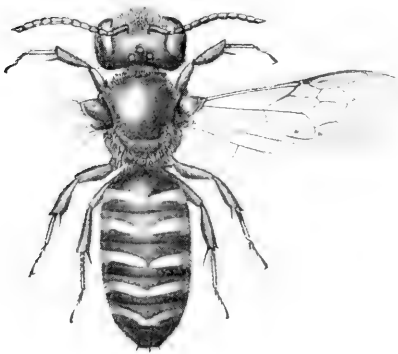


Fig. 123. *Stelis (Chelymia) nitidus* Cress.

These are bees with whitish margins on the dorsal segments of the abdomen. Females of the genus *Stelis*, the only genus in the family, lay eggs in *Osmia*'s cells in blackberry stems, before the rightful owners have oviposited. Thus the egg of *Stelis* is lower down in the mass of food than is the later laid egg of *Osmia*. The larva of *Stelis* grows more rapidly than the *Osmia* larva and eats the latter.

Stelis also preys upon a mason bee, *Chalicodoma*. *Stelis (Chelymia) nitidus* Cress. (see drawing), is a Minnesota species.

MEGACHILIDAE

Same as **Stelididae** but claws simple or in some species with a basal tooth; labrum entirely covered by the clypeus; hind tibiae with two apical spurs.

This family contains the leaf-cutting bees and their parasites, as well as the mason bees. The latter earn their name by constructing small earthen cells in various situations.

The leaf-cutting bee, *Megachile*, is the insect which cuts semi-circular pieces from the edges of rose leaves, and from other tender leaves. These pieces of green leaves are used to line the tunnel which

this bee makes in a pithy stem or in solid wood. The genus is almost cosmopolitan, being found in nearly all parts of the world. It is about the size of a honey bee. Ashmead reported a *Megachile* nest (*Psyche*, Feb. 1894) with "thirty cells arranged in nine rows of unequal length, the largest row contained six cells. There must have been a thousand pieces of leaves used in the above."

The genus *Osmia* is an interesting one; *O. lignivora* bores in maple, forming cells in its burrow. Ashmead, in reporting observations on this species (*Psyche* March 1894), states "the tunnel was over three inches long. . . . contained five cells." *O. lignaria* and *O. pacifica* build cells under stones, while the small *O. simillima* constructs cells in deserted oak galls."

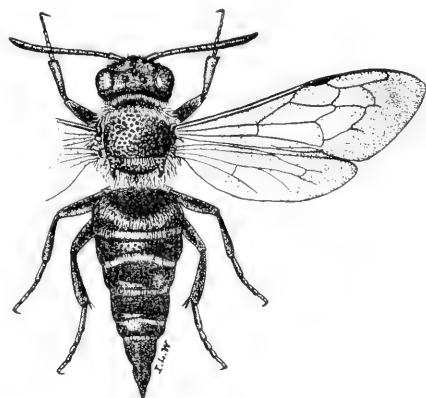


Fig. 124. *Coelioxys octodentata* Say, female.

It will be noted from the above that the diversity of instinct displayed in formation of nests of various species is quite remarkable. They generally choose hollow places already existing, excavations in wood, in the mortar of walls, in sand banks, and elsewhere. *O. tridentata* makes a burrow in the pith of bramble stems.

The following are found in Minnesota either present in our collection, or on record as occurring here: *Heteranthidium chippeawaense* Graen., type-locality—Indian village at junction of the Lower Tamarack and St. Croix rivers, Minnesota. *Alcidamca* sp., *Andronicus* sp., *Coelioxys octodentata* Say (see drawing), *Heriades* sp., *Monumetha*, *Anthidium* sp., *Megachile (Xanthosarus) latimanus* Say (col. pl. 3), *Osmia (Ceratosmia) lignaria* Say, *Coelioxys* sp. taken in Jackson Co. on sunflower and aster Sept. 12.

CERATINIDAE

Females and most males without a flat triangular area on apical dorsal abdominal segment; second recurrent vein never strongly bent or directed outward before joining first portion of subdiscoidal vein; tongue filiform; no depression or foveae on face; wings with three submarginal cells; apex of sixth abdominal segment in female

with a spine; first submarginal cell longer than second, and as long as third; hind tibiae with a sparse pubescence; segments of the abdomen more or less constricted at the sutures.

Small bees, smooth, frequently metallic in coloration (green, blue or blue-black) boring in the pith of briars.

In connection with this and the preceding family and particularly for a discussion of *Osmia*, the student would do well to read Fabre's "Bramble Bees and Others," Dodd, Mead and Co., 1915.

Ceratina dupla Say, occurs here (see col. plate 3), collected by H. L. V. in Rock and Martin counties in September, frequenting asters.

XYLOCOPIDAE

Same as **Ceratinidae**, but with first submarginal cell shorter than second; thorax densely pubescent laterally; hind tibiae with two apical spurs; abdomen not elongate, convex above.

This group contains many of the largest and most powerful of the bees and is widely distributed. The genus *Xylocopa* contains black or blue-black species, robust with shiny integument, more or less covered with hair. *X. virginica* is the large carpenter bee, which bores frequently in solid wood, or even, according to Howard, in lumber and in joists of buildings. These burrows may be one-half inch in diameter, and are sometimes found in beams about porches, sheds, rafters, palings of fences, door frames and window sills.

An interesting statement has been published by Bingham (Brit. Ind. Hymenoptera 1, p. 534), according to which *X. rufescens* Sm. is "crepuscular, on fine moonlight nights its loud buzzing can often be heard all night long." Other bees are known to work at night, notably *Sphécodogastra texana* Cress. On July 15 at Prescott, Wisconsin, these bees were found working on evening primrose as late as 10 p. m. and were not observed upon these or any other flowers in that vicinity during the day time. Both males and females of this species have large ocelli. (S. Graenicher in Bees of Northern Wisconsin, Vol. 1 Art. III, 1911.)

APIDAE

Apical dorsal abdominal segment of males and females, second recurrent vein, depressions of foveae on face, and submarginal cell as in **Ceratinidae**; tongue very elongate, slender and always longer than mentum; apex of sixth dorsal abdominal segment in female without a spine; first submarginal cell shorter than second; cheek or malar space distinct. Hind tibiae with or without apical spurs, thorax densely hairy; three sexes, females (or queens), workers and males.

These are the true bees, most of them social, and most of them storers of honey. Volumes have been written upon the honey bee, *Apis mellifera* L., to which works the reader is referred, for it is mani-

festly impossible to do justice to the honey bee in a report of this kind. For an excellent account of bee management, as well as the ecology of the honey bee, see "The A.B.C. and X.Y.Z. of Bee Culture," latest edition, published by the A. I. Root Co., Medina, Ohio.

The honey bee is distributed practically over the entire globe and it should be borne in mind that there is only one species, the appellations "German," "Italian," "Carniolan," etc., referring simply to strains of the same species.

Next in importance, perhaps, is the group containing the bumble bees, of which over 50 native species are known. A striking characteristic of these bees is the abundant hair covering; and there is a great variation in color of same, as well as in the size of the individuals. They are distinctly social. Males, females and workers exist, the workers not being distinguishable from the females, and if the true queen dies, the smaller females may continue the colony. The nest is made of dry grass or leaves in a hollow in the field in or under old stumps, under boards, or even below the surface of the ground. In the latter case there may be 200 or 300 individuals in a nest, but the colonies on the surface are less populous.

In autumn, large numbers of males are produced, also new queens. The colony as a whole then dies except a few fertilized queens, which survive the winter, each destined to start a new colony in the spring. The eggs first laid produce neuters or workers, later males and productive females are produced. Certain female bees in the colony, smaller than the queen, may help in egg-laying, and this is sure to be the case if the true queen dies. About four weeks elapse between the depositing of the egg and emergence of the perfect insect.

Bumble bees do not use cells twice, but form new cells on the remnants of the old; consequently the nests may be quite bulky. They are destroyed by several animals, either for the honey or for the larvae contained therein. Field mice, weasels, and foxes are the chief marauders.

In the nest are found "honey tubs," "pollen tubs" and the cells of a "friendly parasite," *Psithyrus (Apathus)*, discussed below. Honey is stored in empty pupal cells and in other special receptacles made entirely of wax. Country boys are aware of these stores and rob the nests.

Psithyrus (Apathus) is always found in and about bumble bee nests. It is widely distributed and resembles a bumble bee very closely,

“each species of *Psithyrus* resembling the bumble bee with which it usually lives.” Since the genus only appropriates a portion of the food supply of its host, it may be regarded as a messmate or “commensal” and not a parasite, though sometimes destructive.

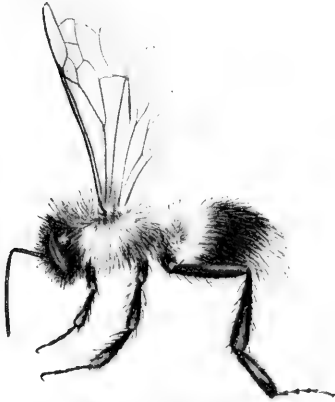


Fig. 125. *Psithyrus ashtoni*
Cress, male.

In observations made on the habits of this bee, it has been observed that it is not as industrious as the bumble bee, only leaving the nest somewhat before noon and returning toward evening, and sometimes passing entire days in the nest, consuming the honey of its host. Since this “boarder” is much larger than its host, and consumes a large amount of honey, the number of bumble bees raised in an infested nest is naturally reduced.

The following species are found in Minnesota either present in our collection, or on record as occurring here: *Bombias auricomus* Rob., *B. separatus* Cress., (col. plate 3), *B. rufocinctus* Cress., *Bremus borealis* Kirby, (col. plate 3), *B. fervidus* F., *B. pennsylvanicus* Deg. *B. affinis* Cress., *B. terricola* Kirby, *B. impatiens* Harris, *B. perplexus* Cress., *B. vagans* Sm., *B. ternarius* Say. (col. plate 3), *Psithyrus ashtoni* Cress., (Fig. 125), *P. insularis* Sm., *P. laboriosus* Cress., (col. plate 3), *Apis mellifera* Linn. (various strains and hybrids.)

Viereck's collecting in 1913 did not add to our list of known Minnesota species of bumble bees. He found the above forms well distributed over the state on aster and sunflower in August and September.

INDEX OF FAMILIES AND SUPERFAMILIES

(Colored plates 1, 2 and 3 face pages 148, 184, 207 respectively.)

Alysiidae	166	Ibaliidae	180
Ampulicidae	215	Ichneumonidae	170
Andrenidae	227	Ichneumonoidea	164
Anthophoridae	230	Larridae	222
Aphelinidae	183	Leucospidae	192
Apidae	234	Macropidae	229
Apoidea	226	Megachilidae	232
Argidae	159	Megalodontidae	155
Astatidae	223	Mellinidae	220
Banchidae	167	Methocidae	207
Belytidae	197	Mymaridae	183
Bembicidae	224	Myromosidae	207
Bethylidae	205	Mutillidae	207
Braconidae	167	Nomadidae	229
Callimomidae	189	Nomiidae	229
Capitoniidae	169	Nyssonidae	216
Ceraphronidae	196	Oryssidae	157
Ceratinidae	233	Oxybelidae	217
Cephalidae	155	Panurgidae	229
Ceceridae	226	Pelecniidae	198
Chalastogastra	152	Pemphredonidae	224
Chalcididae	192	Perilampidae	191
Chalcidoidea	180	Philanthidae	218
Chrysididae	204	Platygasteridae	195
Chrysoidea	203	Psammocharidae	209
Cimbicidae	158	Psenidae	217
Clistogastra	164	Pterygophoridae	162
Colletidae	231	Pteromalidae	186
Crabronidae	217	Sapygidae	206
Cynipidae	179	Scelionidae	196
Cynipoidea	177	Scoliidae	205
Diapriidae	196	Serphidae	197
Diprionidae	159	Serphoidea	195
Dryinidae	205	Signiphoridae	189
Dufoureae	228	Siricidae	157
Elachertidae	186	Spalangidae	187
Elasmidae	186	Sphecidae	220
Emphoridae	230	Sphecoidea	215
Encyrtidae	188	Stelididae	232
Entedontidae	185	Stephanidae	167
Euceridae	230	Tenthredinidae	160
Eucharidae	192	Tenthredinoidea	152
Eulophidae	186	Tetrastichidae	185
Eumenidae	210	Trichogrammidae	184
Eupelmidae	189	Tridymidae	187
Eurytomidae	183	Trigonalidae	170
Evaniidae	169	Trypoxylonidae	220
Figitidae	178	Vespidae	211
Formicidae	202	Vespoidea	204
Formicoidea	198	Vipionidae	165
Halictidae	226	Xiphyriidae	158
Heloridae	197	Xyelidae	155
Hylaeidae	231	Xylocopidae	234

MINNESOTA BARBERRY ERADICATION LAW

GENERAL LAWS OF MINNESOTA FOR 1919

Chapter 81—S. F. No. 120

An act requiring the owner or occupant of premises within this state, on which Mahonia bushes and Barberrry bushes of the rust producing varieties may be grown, to destroy the same, declaring the same to be a public nuisance; imposing certain powers and duties with reference to the same on the state entomologist; and providing penalties for the violation thereof.

Be it enacted by the Legislature of the State of Minnesota:

Section 1. All Barberrry (*Berberis sp.*) bushes and all Mahonia (*Mahonia sp.*) bushes except the species and variety known as Japanese barberrry (*Berberis thunbergii*) are rust producing species and are hereby declared to be, and the same are, a public nuisance and a menace to the public welfare, and their maintenance, propagation, sale or introduction into the state is forbidden. It shall be the duty of every person owning, occupying or having charge of any premises on which such bushes of the rust producing varieties are grown, or at any time found growing, to forthwith destroy such bushes.

Section 2. The state entomologist is authorized, and it is hereby made his duty to cause all such rust producing Mahonia bushes or Barberrry bushes within the State of Minnesota to be eradicated. The state entomologist shall make rules and regulations relating to the most convenient and expedient method of eradicating and destroying such rust producing Mahonia bushes or Barberrry bushes; he shall have the power to appoint one or more agents to enforce the provisions of this act, and he, or his agents, shall have free access at all reasonable hours to any premises to determine whether such rust producing Mahonia bushes or Barberrry bushes are growing thereon, and to require reports from the owners or occupants of any premises as to the presence of such bushes thereon.

Section 3. In pursuance of his powers hereby granted, whenever the state entomologist, or his agents, shall have found Mahonia bushes or Barberrry bushes of such rust producing varieties on any premises, it shall be the duty of the state entomologist, or his agents, as the case may be, to immediately notify or cause to be notified, the owner or occupant of the premises on which such bushes are growing; such notice shall be sent to such owner or occupant in such form as the state entomologist shall prescribe, and if such Mahonia bushes or Barberrry

bushes are not destroyed within ten (10) days after the mailing of such notice, if sent by registered mail, or within eight days after the delivery of such notice, if delivered by messenger, the state entomologist, or his agents, shall destroy or cause to be destroyed such Mahonia bushes or Barberry bushes. The expense of such destruction shall be paid to the state entomologist by the owner of the premises within ten (10) days after the rendition of a bill therefor, and if such cost shall not be paid within said time the bill shall be reported to the county attorney, who shall forthwith collect the same in the name of the state and shall turn the amount collected over to the state treasurer to be credited to the road and bridge fund of the county.

Section 4. The state entomologist, or his agent, may, or whenever requested by any resident of the state, shall determine, or cause to be determined, whether or not the Mahonia bushes or Barberry bushes grown on certain premises are of the rust producing varieties. The said entomologist shall make a certificate of his findings and determination in the premises, which certificate shall be prima facie evidence of the facts therein recited. Such certificate may be received in evidence in any civil action arising under the provisions of this act.

Section 5. Any person violating any of the provisions of this act shall be guilty of a misdemeanor.

Section 6. This act shall take effect and be in force from and after its passage.

Approved March 21, 1919.

SMITHSONIAN INSTITUTION LIBRARIES



3 9088 01272 2302